RMIT UNIVERSITY

AUBEA 2017

THE 41ST AUSTRALIASIAN UNIVERSITIES BUILDING EDUCATION ASSOCIATION CONFERENCE

AUBEA

CONFERENCE PROCEEDINGS

3 - 5 JULY 2016 | WWW.AUBEA.ORG

rmit.edu.au

SCHEDULE

(Click on the paper titles on this schedule to link directly to its abstract)

Monday 3rd July 2017

8.00 - 9.30 am	Registration (Foyer)
9.30 - 9.45 am	Opening Ceremony (Lecture Theatre)
9.45 - 10.45 am	Keynote Speaker - Sai On Cheung (Lecture Theatre)
10.45 - 11.00 am	Morning Tea (Foyer - Outdoor Area)

Presentations

	Room 6 Education and Training	Room 7 Technology	Room 9 Management
	Chair: Ehsan Gharaie	**Chair: Mehrdad Arashpour**	**Chair: Eric Too**
11.05 - 11.20 am	**Paper 043:** An Evidence-Based Interpersonal Competency Assessment Framework (i-CAF) For Construction Education	**Paper 103:** Tall Building Form Optimisation: Designing For Urban Resilience	**Paper 010:** Factors Driving Global Outsourcing Of Materials For The Australian Construction Industry
11.25 - 11.40 am	**Paper 013:** Integrating Interdisciplinary Thinking And Practice: A Case Study Of A Victorian University In Australia	**Paper 004:** Lessons For The Off-Site Manufacture Of Houses In Australia	**Paper 016:** Early Contractor Involvement (ECI) In Event Planning And Management
11.45 am - 12.00 pm	**Paper 006:** Instilling Resilience In Built Environment Students	**Paper 063:** Form And Performance: Tall Concrete Structures And Apartment Quality In Melbourne's Residential Towers	**Paper 033:** Engineering And Construction Expertise Transfusion At The U.S. Army Corps Of Engineers: A KM Case Study
12.05 - 12.20 pm	**Paper 011:** Building Stem Skills In Built Environment Education	**Paper 107:** Prefrabrication Technique For Low Cost Housing In Assam	**Paper 038:** A Method To Measure The Size Of The Australian Built Environment Sector

12.20 - 1.20 pm	Lunch
1.20 - 1.50 pm	ABCB - NCC Session (Lecture Theatre)

Presentations

	Room 6 Education and Training	Room 7 Technology	Room 9 Management
	Chair: Usha Iyer-Raniga	**Chair: Frank Boukamp**	**Chair: Tayyab Maqsood**
1.55 - 2.10 pm	**Paper 036:** Meeting Changing Industry Expectations From Australian Property Valuation Graduates	**Paper 130:** The Impact Of Individual Beliefs And Expecations On BIM Adoption In The AEC Industry	**Paper 017:** An Ethnographic Investigation Into A Series Of Incidents On A Large Construction Project
2.15 - 2.30 pm	**Paper 134:** Improving The Student Experience With Learning Analytics In Construction Project Management Courses	**Paper 076:** Preliminary Investigation Of The Residential Housing Contractors' View Of The Adoption Of BIM Technology	**Paper 019:** Institutional Roles In Effective Statutory Adjudication Implementation
2.35 - 2.50 pm	**Paper 029:** Virtual Learning Platforms: Assisting Work Integrated Learning	**Paper 085:** Towards Managing Iterative Changes In BIM Collaboration Workflows	**Paper 021:** Essential Site Coordination Problems In Hong Kong Building Projects
2.55 - 3.10 pm	**Paper 056:** Fostering Student Work Readiness - A University Case Study	**Paper 030:** Improving Buildings Facility Intelligence In Higher Education Precinct: A SocioBIM Approach	**Paper 055:** Inclusion And Wellbeing For People With Autism And The Role Of Built Environment

3.15 - 3.35 pm	Afternoon Tea (Foyer - Outdoor Area)

Presentations

	Room 6 Education and Training	Room 7 Technology	Room 9 Management
	Chair: Mary Hardie	**Chair: Tayyab Maqsood**	**Chair: Peter Wong**
3.35 - 3.50 pm	**Paper 054:** Leading The Way: Peer To Peer Mentoring To Improve The Student Experience And Adaptability Through Change	**Paper 102:** A Change Management Perspective On The Implementation of BIM For FM	**Paper 008:** Comparing Continuance Commitment In A Project Orientated Organization.
3.55 - 4.10 pm	**Paper 080:** Global Mobility Experience Of Outbound Construction Management Students: The Case Of Western Sydeny University	**Paper 089:** Modelling User Perception Of Online Visualisation In Real Estate Marketplaces	**Paper 035:** The Core Functions Of Project Governance
4.15 - 5.00 pm	**Paper 106:** Significance Of Culture And Education In Developing Smart Villages In India	**Paper 131:** Training Transfer As The Result Of Rational Decision-Making Process	**Paper 099:** Structural Equation Model Of Strategies For Successful Stakeholder Management In PPPs
5.05 - 5.20 pm	**Paper 129:** Factors Affecting Construction Students' Satisfaction With Grades In Design Courses	**Paper 062:** BIM Education - Case New Zealand	**Paper 116:** Critical Review Of Factors Affecting The Quality Of Build In Residential Volume Building

Tuesday 4th July 2017

9.00 - 10.00 am	Industry Speaker - Luke Stambolis, Managing Director, Probuild (Lecture Theatre)
10.00 - 11.00 am	Industry Speaker - Peter Wilkinson, Melbourne Metro Rail Authority (Lecture Theatre)
11.00 - 11.15 am	Morning Tea (Foyer - Outdoor Area)
11.15 am - 12.15 pm	Industry Speaker - Amalia Athanassopoulos, Design Manager, Dandenong Rail Crossing Project (Lecture Theatre)
12.15 - 1.15 pm	Industry Speaker - Kevin McCarthy, Deputy Director, Capital Works, RMIT NAS Project (Lecture Theatre) Industry Speaker - Marcus Bailey, Associate Director, Donald Cant Watts Corke, Project Director, RMIT NAS Project
1.15 - 2.15 pm	Lunch Albert Chan Information Session (Room 6)

Presentations

	Room 6 **Education and Training**	**Room 7** **Technology**	**Room 9** **Management**
	Chair: Christina Scott-Young	**Chair: Eric Too**	**Chair: Rebecca Yang**
2.20 - 2.35 pm	**Paper 002:** Resetting The Compass: An Immersive Intervention To Develop Abilities In Construction Management	**Paper 003:** Decision Making Of Carbon Reduction Strategies Adoption – A Case Study In Greater Melbourne Region	**Paper 050:** Use Of Timber Prefab System For Ensuring Sustainable Residential Housing Supply In New Zealand
2.40 - 2:55 pm	**Paper 086:** Individual Risk Attitudes In Postgraduate Risk Management Education	**Paper 133/139:** Overview And Analysis Of Digital Technologies For Construction Safety Management	**Paper 073:** Application of RFID In the Prefabricated Timber Industry
3.00 - 3.15 pm	**Paper 126/134:** Improving The Student Experience With Learning Analytics In Construction Project Management Courses	**Paper 110:** "If You Cannot Measure It, You Cannot Control It" – Buildability And Performance-Based Appraisal	**Paper 078:** Understanding The Benefits Of Constructing A Residential House With A Heart Of Cold-Formed Steel
3.20 - 3.35 pm	**Paper 132:** Appraising Constructive Alignment In A Construction Management Programme		**Paper 118:** Electrical And Mechanical Safety In Repair, Maintenance, Alteration And Addition (RMAA) Works

3.40 - 3.55 pm	Afternoon Tea (Foyer - Outdoor Area)
5.45 - 6.30 pm	MCG Tour (Melbourne Cricket Ground, Gate 3)
6.30 pm	Gala Dinner (Melbourne Cricket Ground, Olympic Room and Betty Cuthbert Lounge [Level 2])

Wednesday 5th July 2017

Presentations

	Room 6 **Education and Training**	**Room 9** **Management**
	Chair: Linda Kestle	**Chair: Peter Wong**
9.00 - 9.15 am	**Paper 051:** Development Of A Collaborative Training Partnership In The NZ Construction Industry	**Paper 023:** Improving Australian Commercial Property Market Forecasting By Mapping Structural Changes In Built Environment
9.20 - 9.35 am	**Paper 070:** Seasonal Usage Pattern Of Outdoor Spaces In Educattional Precincts	**Paper 046:** Profitability Of Large Commercial Construction Companies In Australia
9.40 - 9.55 am	**Paper 128:** Rural Construction Management For Developing Economies: Implicatons For Professional Education - The Case Of Assam	**Paper 053:** The Australian Residential Property Market: A Study On Foreign Real Estate Investment
10.00 - 10.15 am	**Paper 018:** Preparing Students For A Disruptive Construction Future	**Paper 071:** The Link Between Facility Maintenance And Work Stress/Satisfaction In Residential Aged Care
10.20 - 10.35 am	**Paper 108:** A Framework For Successful Implementation Of Green Supply Chain Management (GSCM) In Construction Organisations	**Paper 114:** An Investigation Of Disruptive Technology Adaption In Property Management
10.35 - 10.45 am	Morning Tea (Foyer - Outdoor Area)	

Presentations

	Room 6 **Education and Training**	**Room 9** **Management**
	Chair: Neville Hurst	**Chair: Jan Hayes**
10.45 - 11.00 am	**Paper 109:** A Framework For Property Developers To Survive In A Recession	**Paper 064:** Identifying Barriers To Retaining Female Professionals In Engineering And Construction Organisations
11.05 - 11.20 am	**Paper 066:** Comparative Study Of Traditional And Compressed Scheduling On Undergraduate Construction Student's Performance	**Paper 069:** Consultative Design As An Approach Towards Socially Sustainable Residential Aged Care
11.25 - 11.40 am	**Paper 122:** Identifying The Regional Segmentation Of Retirement Villages In Four Australian States From The Market Perspective	**Paper 084:** Modelling Green Technology Adoption Based On Sustainable Construction Practices
11.45 am - 12.00 pm	**Paper 098:** Working In The Residential Sector: Anecdotes Of A 'Boss Lady' On Site	**Paper 125:** Exploring The Implications Of Urban Vulnerability To Incidents Of Buildings Collapse For Construction Safety Research

12.00 - 1.30 pm	Lunch
1.30 pm	Conference Closing

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Acknowledgement of Country

RMIT University acknowledges the Wurundjeri people of the Kulin Nations as the Traditional Owners of the land on which the University stands. The University respectfully recognises Elders both past and present. RMIT also acknowledges the Traditional Custodians of lands across Australia where it conducts its business, their Elders, Ancestors, cultures, and heritage.

Disclaimer: Published by RMIT University Australia June 2017. The information in this publication was correct at time of printing however is subject to change.

CRICOS Code: 00122A
RTO Code: 3046

WELCOME FROM AUBEA

Welcome to the 41ST AUBEA conference

As we all know, higher education is going through tumultuous times. The construction industry is also experiencing its own challenges. Our Australasian Universities Building Education Association Conference has surveyed for 41 years in this environment - and we sincerely hope that this conference will contribute to its longevity! To the best of my knowledge, no other academic construction-related organisation has managed to last so long.

This year's conference celebrates this unique anniversary. RMIT University, have worked tirelessly and professionally to organise the event. You will have the opportunities to listen to and discuss a wide range of topics with your colleagues. We have organised several activities and we hope you will enjoy yourself, meet, and socialise with those you have not seen since last AUBEA.

Josua Pienaar
AUBEA Chair

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Welcome from AUBEA

WELCOME FROM RMIT

RMIT University is a global university of technology, design and enterprise

RMIT University is proud to host the 41st annual AUBEA Conference focusing on *Transforming Built Environment Education and Practice: Leveraging Industry Partnerships*. We welcome all the distinguished speakers and participants.

RMIT University is one of Australia's original tertiary institutions; RMIT University enjoys an international reputation for excellence in professional and vocational education, applied research, engagement with the needs of industry, and the community.

RMIT has a unique approach to meeting the challenge of being ready for life and work: we offer an education deeply grounded in ideas and cross-disciplinary understanding, applied through innovative, enterprising practice to solving problems and meeting the needs of our community.

We are appreciative of all the speakers and participants that make the conference possible. We hope you have an enjoyable experience at the 41st AUBEA Conference.

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Welcome from RMIT

ORGANISING COMMITTEE

Organising Committee

Professor Ron Wakefield, RMIT University

Professor Josua Pienaar, CQUniversity Australia

Associate Professor Usha Iyer-Raniga, RMIT University

Associate Professor Tayyab Maqsood, RMIT University

Associate Professor Peter Wong, RMIT University

Dr Christina Scott-Young, RMIT University

Dr Eric Too, RMIT University

Mrs. Marsha Lamb (Secretariat), RMIT University

Mrs. Elima Pozenel (Secretariat), RMIT University

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ABOUT AUBEA

About AUBEA

The Australasian Universities Building Education Association (AUBEA), a membership-based non-profit organization, was established in 1975 to promote and improve teaching and research in building through communication and collaboration. It comprises academics representing all universities throughout Australasia which provide education in building-related fields in Australasian and beyond. AUBEA maintains a strong connection to industry and professional associations, and since its inception has organised annual conferences.

The annual conference brings together building and construction researchers, educators, students, and industry from Australasia and other regions, and provides them with a strong platform for knowledge sharing, collaboration, disciplinary reflections, institutional exchange, and collective growth.

Papers submitted to this conference have been double-blind peer reviewed before final acceptance to the conference.

AUBEA Council Meeting

The AUBEA Council Meeting will be held on Tuesday 4 July from 2.15 pm.

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About AUBEA

CONFERENCE THEMES

The conference theme for the AUBEA 2017 Conference is *Transforming Built Environment Education and Practice: Leveraging Industry Partnerships in the Built Environment*. We invite AUBEA participants to engage in discussion about *Leveraging Industry Partnerships* and how they can provide opportunities for communities of innovation.

Education and Training (E&T)

- New and emerging learning and teaching technologies/philosophies
- Visualisation and augmented reality applications for Built Environment education
- Engaging students as partners in education design and delivery
- Innovation and challenges in learning and teaching
- Designing an industry relevant curriculum
- Enhancing employability of Built Environment graduates
- Building resilience of Built Environment graduates
- Sustainability in a Built Environment curriculum
- Engaging students in Built Environment research and practice

Technology (TECH)

- New and emerging techniques/technologies for the Built Environment such as:
  - Building Information Modelling
  - Automation and Robotics
  - Laser Scanning
  - 3D Printing
  - Augmented and/or mixed reality
  - Offsite construction/Prefabrication
- Innovation in building design
- Challenges for building regulations, legislation and licensing
- Building materials, building facilities and services

Management (MGT)

- Leadership in the Built Environment
- Legal issues in the Built Environment
- Sustainability in the Built Environment
- Work health and safety issues in the Built Environment
- Cultural issues in the Built Environment
- Integrated project delivery
- Supply chain integration
- Managing knowledge and organisation learning
- Social issues in construction (gender diversity, ageing workforce, substance abuse etc)
- Ethical issues in the Built Environment
- Collaborative forms of procurement (relational contracting/partnering/alliancing) in the Built Environment
- International issues in the Built Environment
- Mega projects
- Disaster reconstruction

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Conference Themes

KEYNOTE SPEAKERS

Academic

Professor Sai On Cheung DSc, PhD, FRICS, MASCE

Professor Sai On Cheung is the director of the Construction Dispute Resolution Research Unit (CDRRU), Department of Architecture and Civil Engineering, City University of Hong Kong. Professor Cheung is also a specialty editor of Contracting of the ASCE Journal of Construction Engineering and Management, and associate editor of the ASCE journal of Legal Affair and Dispute Resolution in Engineering and Construction. Professor Cheung has developed research programs in contract and dispute management. Some of the studies conducted by the CDRRU have been published in research monographs – “Trust in Co-operative Contracting in Construction”, “Construction Dispute Research: Conceptualisation, Avoidance and Resolution”, and “The Soft Power of Construction Contracting Organisations”.

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Keynote Speakers

Industry Session Information

The industry session will commence with the keynote industry speakers providing an insight into current major projects. The session will provide a valuable opportunity for conference delegates to engage in an interactive Q&A session examining these projects.

Industry

Luke Stambolis - Managing Director - Probuild

Luke's extensive experience includes several major retail projects in Australia and the UK, more than 1,600 apartments and some of Melbourne's most prominent CBD skyscrapers. He has worked in many roles, on both the contractor and developer side, and has a deep understanding of what it takes to ensure project delivery success.

Luke is used to leading multiple teams through difficult and complex issues such as construction techniques, buildability in design, and design and logistics planning for optimal project speed. Luke coordinates project outcomes for developers, financiers, and authorities, ensuring PPRs are being met and stakeholder issues are quickly resolved.

Industry

Peter Wilkinson - Director Development & Delivery - Melbourne Metro Rail Authority

Peter Wilkinson has nearly 30 years' experience in delivering major infrastructure projects both within Australia and overseas. He is currently overseeing the design and delivery of the proposed construction program for the Metro Tunnel Project. His rail experience in Melbourne includes the delivery of rail/road grade separations at Middleborough Road in Box Hill and Springvale Road in Nunawading, rail duplication and extension to South Morang, as well as the major brownfield works on the Regional Rail Link Project.

Prior to his current role, Peter was with John Holland Constructions for 28 years, with his most recent roles as Alliance General Manager delivering complex public infrastructure projects across Melbourne.

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Keynote Speakers

Industry

Amalia Athanassopoulos - CPB Contractors Digital Engineering Lead, Caulfield to Dandenong - Level Crossing Removal

CIMIC Group company, CPB Contractors, with its Alliance partners, were selected by the Level Crossing Removal Authority (LXRA) as the preferred consortium to design and construct the Level Crossing Removal Project: Caulfield to Dandenong in Melbourne.

The project will remove nine level crossings between Caulfield and Dandenong in Melbourne's south-eastern suburbs and see five railway stations rebuilt at Carnegie, Murrumbeena, Hughesdale, Clayton and Noble Park. Power and signalling upgrades will also be carried out between Flinders Street Station and Pakenham Station.

CPB Contractors delivers major projects across all key sectors of the construction industry, including roads, rail, tunnelling, defence and building.

Industry

Kevin McCarthy - Deputy Director, Capital Works - Property Services, RMIT University

Kevin McCarthy is the Deputy Director of the Capital Works Department within RMIT University Property Services and has led the investment of over $1B in built infrastructure over his 8 years with the University.

A number of these projects within this portfolio have received national and international recognition via industry awards and have materially improved the collective University experience.

The New Academic Street project provides a strong foundation for delivering an ever-improving student experience at RMIT's flagship City campus.

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Keynote Speakers

Industry

Marcus Bailey - Associate Director, Donald Cant Watts Corke - Project Director, NAS, RMIT University

Marcus is an Associate Director with Donald Cant Watts Corke and has over 20 years' architectural and project management experience.

Marcus has extensive major project and Tertiary Education experience having worked on the Swanston Academic Building and more recently the New Academic Street (NAS) projects for RMIT.

Marcus is currently the NAS Project Director and has worked extensively on the delivery strategy including staging, consequential and enabling works. He has been the key Stakeholder Manager since the inception of the project and reports directly to the Chair of the NAS Project Control Group.

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Built.

AUBEA 2017 PROGRAM IN BRIEF

Monday 3rd July

8.00 - 9.30 am	Registration	Foyer
9.30 - 9.45 am	Opening Ceremony	Lecture Theatre
9.45 - 10.45 am	Keynote Speaker - Sai On Cheung	Lecture Theatre
10.45 - 11.00 am	Morning Tea	Foyer - Outdoor Area
11.00 am - 12.20 pm	Paper Presentations (3 sessions running concurrently)	Various Locations
12.20 - 1.20 pm	Lunch	Foyer - Outdoor Area
1.20 - 1.50 pm	ABCB – NCC Session	Lecture Theatre
1.55 - 3.10 pm	Paper Presentations (3 sessions running concurrently)	Various Locations
3.15 - 3.30 pm	Afternoon Tea	Foyer - Outdoor Area
3.35 - 5.20 pm	Paper Presentations (3 sessions running concurrently)	Various Locations

Tuesday 4th July

9.00 - 10.00 am	Industry Speaker - Luke Stambolis	Lecture Theatre
10.00 - 11.00 am	Industry Speaker - Peter Wilkinson	Lecture Theatre
11.00 - 11.15 am	Morning Tea	Foyer - Outdoor Area
11.15 am - 12.15 pm	Industry Speaker - Amalia Athanassopoulos	Lecture Theatre
12.15 - 1.15 pm	Industry Speaker - Kevin McCarthy, Marcus Bailey	Lecture Theatre
1.15 - 2.15 pm	Lunch Albert Chan Info Session	Various Locations Room 6
2.15 - 3.35 pm	Paper Presentations (3 sessions running concurrently) AUBEA Council Meeting	Various Locations
3.40 - 3.55 pm	Afternoon Tea	Foyer - Outdoor Area
5.45 - 6.30 pm	Tour of MCG	MCG
6.30 pm	Gala Dinner	MCG

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Wednesday 5th July

9.00 - 10.35 am	Paper Presentations (3 sessions running concurrently)	Various Locations
10.35 - 10.45 am	Morning Tea	Foyer - Outdoor Area
10.45 am - 1.00 pm	Paper Presentations (3 sessions running concurrently)	Various Locations
12.15 - 1.30 pm	Lunch Closing of Conference	Foyer - Outdoor Area Lecture Theatre

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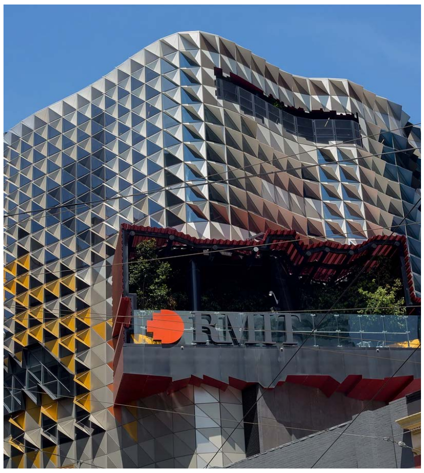
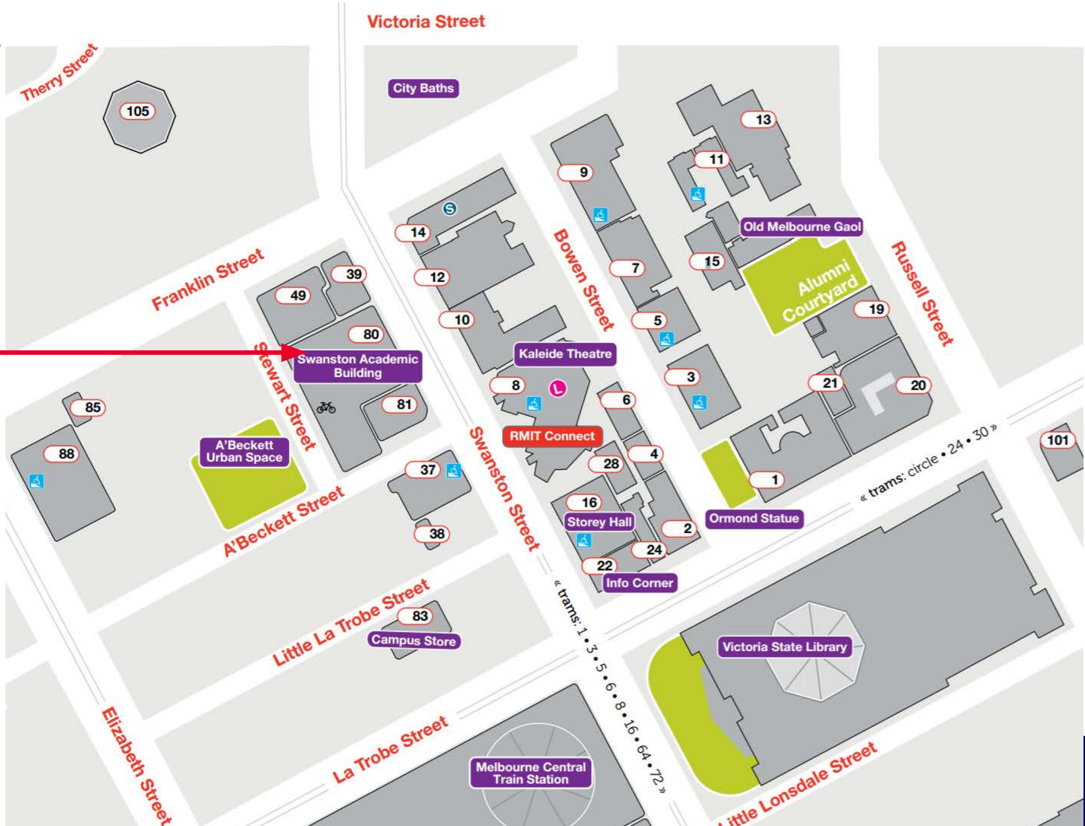
CONFERENCE VENUE

RMIT UNIVERSITY
Swanston Academic Building
Building 80, Level 7
445 Swanston Street, Melbourne



Melbourne City campus is located in the cosmopolitan heart of the “world’s most liveable city” and is surrounded by public transport, restaurants, cafes, theatres, galleries and parks.

Our City campus has 45,000 students studying in many programs across all major interest areas. The campus has been an integral part of Melbourne’s character for more than one hundred years.



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GALA DINNER

Gala Dinner

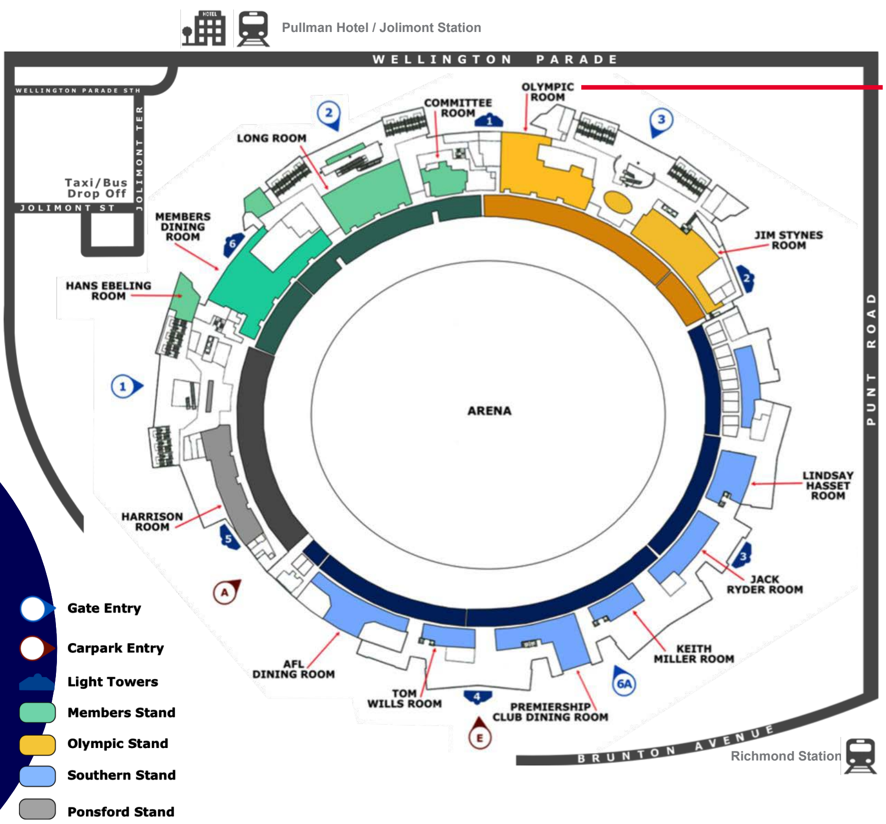
Date: Tuesday 4th July
Time: 6.30 pm
Venue: Olympic Room & Betty Cuthbert Lounge (Olympic Stand Level 2)

The Melbourne Cricket Ground (MCG) is steeped in a rich history; established in 1853, less than 20 years after the founding of Melbourne, it is often described as the beating heart of this fantastic city.

It has been the home of Australian football since 1859, and was the birthplace of Test cricket in 1877 and one-day international cricket in 1971.

It was the main stadium for the 1956 Olympic Games and 2006 Commonwealth Games, attracts up to 100,000 fans to the annual AFL Grand Final, and the "G" comes to life each Christmas at the Boxing Day Test.

Other sporting spectacles to have been held there include World Cup soccer qualifiers, rugby league home and away matches and State of Origin, international rugby union, and Austral Wheel Races.



Olympic Room & Betty Cuthbert Lounge Level 2

Gate Entry – Gate 3

MCG Parking – Entrance A off Brunton Avenue
Please use lifts 9,10,11 to access the Olympic Room

IF COMING TO THE GROUND BY
TRAIN – RICHMOND STATION
Exit station, cross Punt road, walk towards the MCG via Brunton Ave, go up the stairs, enter at the above allocated room gate

TRAIN – JOLIMONT STATION
TRAM – FROM WELLINGTON PARADE
Exit station; walk through the park towards the MCG, enter at the above allocated room gate

TRAM FROM OLYMPIC PARK
Get off at Rod Laver, walk up the ramp to footbridge to the MCG, enter at the above allocated room gate

TAXI
Ask to be dropped off at Jolimont Terrace and Jolimont St, enter at the above allocated room gate

PUBLIC PARKING FACILITIES
1. MOPT - Entrance D off Olympic Boulevard
2. Federation Square – cnr Flinders & Swanston St
3. City Square – 202-208 Flinders Lane
4. Metered parking in area – Jolimont St, Jolimont Terrace, Clarendon St

BRUNTON AVENUE - Car parking
Right hand turns into parking entrances are ILLEGAL

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TOUR THE MCG

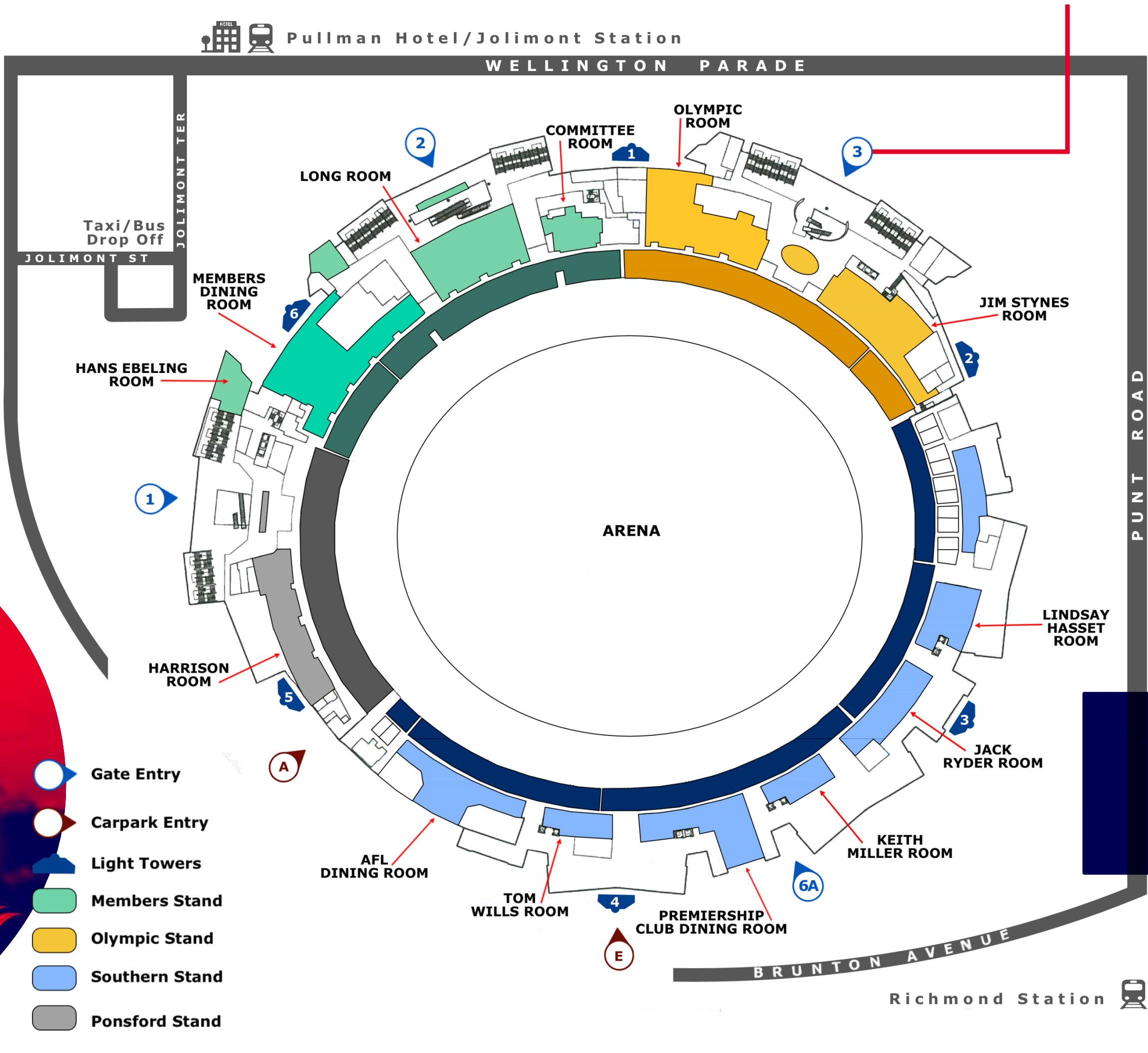
Tour the MCG

Date: Tuesday 4th July
Time: 5.45 – 6.30 pm
Venue: Melbourne Cricket Ground, Gate 3

We have organised a guided tour of the MCG. Explore the inner sanctum, walk on the hallowed arena, and experience where legends play by taking this tour!

Highlights of this must-see tour include:
The famous MCC Long Room
MCC Library (founded in 1873)
MCG Tapestry
Player change rooms
Cricketers' viewing room
Ron Casey Media Centre
Portrait of Sir Donald Bradman and Sachin Tendulkar
A walk on the arena
Cricket Victoria Bill Lawry Centre
Ponsford Stand
City Terrace with views of Melbourne's skyline.

Tour commences at Gate 3 at 5.45 pm. Please arrive early.



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CONFERENCE GENERAL INFORMATION

Registration Desk Hours

Monday 3rd July, 2017, 8.00 – 9.30 am
Tuesday 4th July, 2017, 8.00 – 9.00 am
Wednesday 5th July, 2017, 8.00 – 9.00 am

Keeping to Time

As a courtesy to presenters, please do not enter or leave a session room during a presentation. Please ensure that you remain in the room until the presentation has concluded, and then you are welcome to leave during the presenter changeover.

Cameras/Electronic Recording and Mobile Phones

As a courtesy to other participants, please ensure that all mobile phones are turned off or on silent mode during all presentations.

Conference Catering And Dietary Requirements

Lunches, morning and afternoon teas will be held in the outdoor area (weather permitting) off the foyer of level 7 as an informal stand up buffet. Please advise of any dietary requirements at time of registration. Please note that dietary requirements for the Gala Dinner will not be provided if not advised previously.

Name Badges

Please wear your name badges at all times during the conference and social events. You will be asked to present your name badge to enter the Gala Dinner and MCG Tour.

Photography

An official photographer will take photographs throughout the conference and they may be published on the Conference website and conference social media pages.

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Internet Access

WIFI during the conference can be accessed by login on using the following information below

Network: x80471
Password: rmit?1234

Smoking

RMIT University is a smoke free zone. You can smoke outside the building on Swanston Street.

Emergency Evacuation Procedures

In the event of an emergency, delegates will be advised to take the nearest accessible emergency exit. Please refer to the evacuation maps in the building.

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PRESENTERS INFORMATION

Session Information

Please introduce yourself to your session chair in the allocated room 15 minutes before your session is due to begin.

You are expected to give a 5 minute presentation of your work. We strongly suggest that you restrict the number of PowerPoint slides in your presentation to 3 or 4.

Time

Each presentation has been allocated a total of 15 minutes to complete, (5 minutes + 10 minutes Q&A + 5 minute changeover). Ensuring that your presentation is delivered in accordance with the time allocated with greatly assist in maintaining the conference schedule. Each session chair will be keeping strictly to the programme.

Presentations

If you have videos or animations in your PowerPoint format, please ensure you have embedded the files in your presentation. Without doing this, your video will not function. WMI or AV file types are recommended. Save your Power Point presentation file onto a USB flash drive, bring it to the conference. At the time of registration a copy will be made that will be uploaded to the computer where you will be presenting.

Presentation Equipment

Each presentation room features standard audio-visual equipment, including projection screens, digital projectors, Windows 7, computer and speakers. For Apple Mac users, please ensure your presentation is capable of running on Windows 7.

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LUNCH SPONSOR

The AUBEA 2017 Conference would like to thank the following oranisations for their generous contributions.

Australian Institute Of Quantity Surveyors (AIQS)

The Australian Institute of Quantity Surveyors (AIQS) is a professional standards body with over 4,000 members. Through its leadership, standards, and Code of Professional Conduct, it ensures that AIQS Quantity Surveyors are dedicated to maintaining the highest standards of professional excellence.

With branches across Australia and internationally, the AIQS actively engages with all levels of Government, Financial Institutions, major corporate institutions, and the building, infrastructure, utility and mining sectors. It is also the Australian peak body to the International Cost Engineering Council (ICEC) and the Pacific Association of Quantity Surveyors (PAQS).

Publications
The Institute plays an important role in industry research through the collection of cost data and the publishing of the Building Cost Index (BCI), printed in the quarterly magazine The Building Economist which was first produced in 1961. In addition, the Institute publishes relevant industry textbooks and guides for use in the teaching & practice of quantity surveying techniques.

Latest publications include:

- Australian Standard Method of Measurement of Building Works (6th Edition)
- Detailed Building Measurement – Volume 1 & 2

Other publications include the Australian Cost Management Manual and a series of useful technical guides and textbooks, as well as videos, CDs and Practice Notes.

AIQS
AUSTRALIAN INSTITUTE OF QUANTITY SURVEYORS

The AIQS Academy
The AIQS Academy is an on demand, online training portal of 100 topics available for all professionals.

Each topic involves reading materials and a narrated presentation, followed by an assessment to ensure participants meet the required level of competency.

Students and lecturers can use The Academy to supplement existing teaching methods and improve knowledge in the core competencies of Quantity Surveying.

For more information on The Academy visit www.aiqsacademy.com

Membership
Are you interested in becoming a member of the AIQS? Membership pathways exist for those engaged in teaching quantity surveying.
Visit www.aiqs.com.au or email membership@aiqs.com.au for more information.

Contact
Australian Institute of Quantity Surveyors
Lani Kirby
Education and Events Manager
Tel: +61 2 8234 4000
Email: education@aiqs.com.au
Website: www.aiqs.com.au

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LUNCH SPONSOR

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SPONSORS

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ABSTRACTS

Paper ID 002

Resetting the compass: An immersive intervention to develop abilities in Construction Management

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Abstract
Students' post-intervention perceptions of an event provide insight relative to their understanding and appreciation of the intervention, as well as the impact thereof.
Experience and anecdotal evidence indicate that Honours students experience challenges in terms of completing the academic year.
The purpose of the study reported on is to determine the impact of a one- day team building event on participants directed at, inter alia, developing their ability to manage themselves, work as a team, and interface with each other, and their ability to strategise, plan, evolve tactics, and take action, based upon a self-administered questionnaire survey conducted in a South African university. The students were surveyed after the completion of the event.
The salient findings include - the team building activities impacted on participants in many ways, contributed to an enhancement of their ability to strategise, plan, evolve tactics, and take action, and participants enjoyed and benefited from the team building activities.
It can be concluded that the one-day team building event had the desired impact in terms of the development of participants' ability to manage themselves, work as a team, and interface with each other, and their ability to strategise, plan, evolve tactics, and take action.
It is recommended that the one-day team building event continue to be staged at the beginning of the Honours year, and that the post-event research be conducted on an annual basis.

Keywords
actions, construction management, students, survey, team building

Paper ID 003

Decision Making Of Carbon Reduction Strategies Adoption – A Case Study In Greater Melbourne Region

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Abstract
Contractors convert design into reality. They are presumed as a major contributor of carbon emissions from the construction development. Carbon reduction strategies were proposed in previous studies. Nevertheless, contractors were often criticised for standing aloof to adopt them. Some argued that the contractors may not have contractual leverage to challenge the decisions made by the developers and the consultants. Nonetheless, there has been a lack of research that focuses on how different construction project organisations (CPOs) may be affecting carbon reduction strategies adoption. This paper presents a study that investigates the effect of the construction project organisations have on the contactors' adoption of carbon reduction strategies. An industry survey was conducted in Melbourne, Australia. 200 questionnaires were sent to the registered contractors. Monte Carlo simulations were conducted to examine how the priorities of strategies adoption may be affected by the CPOs. The results indicate that developers and the design consultants are influential to contractors' decision in adopting those carbon reduction strategies that may incur additional project cost. The results indicate that decisions towards the adoption of strategies may not be swayed towards their effectiveness of achieving carbon reduction. Instead, tightening planning and building regulations might affect decisions.

Keywords
carbon reduction, construction project organisations

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Paper ID 004

Lessons For The Off-Site Manufacture Of Houses In Australia

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Abstract

In Australia, the current traditional construction industry struggles to supply housing to satisfy increasing demand. Literature indicates that house construction completion times using traditional methods are increasing due to a number of factors. These include an increasing decline in the numbers of skilled workers, a lack of innovation in the industry and a disjointed framework for efficient production. It is often suggested that the increased use of off-site manufacture (OSM) to produce housing will assist in solving the demand issues Australia is facing. This paper focuses on detached housing which represents 70% of the housing production in Australia (ABS, 2009). OSM for housing is defined in this paper as all components manufactured, services installed and finishes completed in a factory ready for transport to site and assembly on-site in a short time frame. The study described here, seeks to identify factors to further inform the discussion of OSM so that it can be evaluated in the Australian context. The paper has examined five countries experiences of OSM of housing, and distilled the factors which influenced the success and failure of OSM in those countries. Successful introduction of OSM housing is arguably possible through use of the application of the criteria and variables presented in this paper.

Keywords

housing, off-site manufacturing, traditional construction

Paper ID 006

Instilling Resilience In Built Environment Students

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Abstract

Upon graduation from University many students lose access to support structures such as peers, academic mentoring, etc. This may lead to tension, stress and failure to perform effectively in their new workplaces, especially if the workplace itself is stressful, as it is in construction. Evidence indicates that the construction sector is a uniquely stressful environment, where the development of resilience is imperative for success. There is currently a perception that the development of resilience skills is not included as learning outcomes within units of study within the built environment discipline. In order to determine the scope and depth of resilience within construction curricula, staff and students from seven universities were interviewed using a semi structured instrument. These interviews were preceded and followed by industry roundtable discussions to contextualize enhanced learning opportunity and benefit. Emerging themes suggest that there are many opportunities to provide resilience learning within curricula with little adaptation required. Examples of useful case study type introductions to industry that may bolster students were provided by the interviewees. These examples are utilized in a Resilience Toolkit that is outlined. Noteworthy advice from students regarding best practice lecturing suggests that an academic with a balanced career path, comprising both industry experience or industry contacts to draw from, together with academic standing appears to provide a learning experience best suited to incorporate resilience behaviours and requisite training.

Keywords

resilience, coping, construction, curricula, built environment

(Click on the abstract titles to link directly to the full paper)

Paper ID 008

Comparing continuance commitment in a project orientated organization

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Abstract
Organizational commitment is recognised as having a positive relationship with employee retention and performance, yet the nature of commitment in a project-orientated organization is unknown. Project orientated organizations are complicated by temporary teams, varying workloads and inability to guarantee future projects. To date, research in project orientated organizations treats employees as an homogenous body. Adopting a case study methodology, this research explored organizational commitment within a project organization, comparing staff within the organization. Employees were asked to complete an online instrument measuring affective, normative and continuance commitment. Analysis compared results from project managers, project staff and support staff. The research found that project managers reported stronger affective commitment; support staff reported the strongest normative and continuance commitment. The concept of self-investment by employees in the organization is explored as a possible cause of high continuance commitment amongst support staff. Project organizations can use this information to enhance their management of employees. It is important for an organization with project and non-project employees to understand and meet the needs of different roles. The research concludes that the projectification of organizations has wider human resource management and productivity implications and requires further investigation

Keywords
commitment, organization, project

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Paper ID 010

Factors Driving Global Outsourcing Of Materials For The Australian Construction Industry

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Abstract

The Australian construction industry sources products from overseas to obtain a local cost-competitive advantage however it faces barriers and negative risks with this strategy. This study of seven successful Melbourne based importers of construction products found that they shared many of the same drivers, benefits and barriers reported in the literature, developing their own mitigation strategies to combat the risks. New factors identified but not previously reported were the inept behavioral practices of local suppliers compared to the ease of doing business and the superior ethical business practices of overseas suppliers. This suggests that local suppliers would struggle to meet the standard of service set by their overseas competitors.

Keywords

offshore sourcing, construction products, risk mitigation

Paper ID 011

Building Stem Skills In Built Environment Education

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Abstract

Australia is on the cusp of a range of global megatrends across technology, society, the economy, and the environment which are changing the world of work for future graduates beyond current recognition. Digitisation, technology and automation are requiring new skills at a rate of exponential change. Many of these skills have traditionally been classified as skills related to STEM disciplines. But future employability is now linked to the growing demand for 21st century STEM skills beyond existing traditional understandings of STEM. It will not only be STEM graduates who will need 21st century skills of discipline literacy, adaptive thinking, proficiency in coding and technology, utilising a design mindset, complex problem-solving and analytical thinking skills. All students, including built environment graduates, will need adaptive thinking about their worlds and exposure to 21st century STEM skills and understandings. This research work by members of the OLT funded STEM Ecosystem illustrates the development of STEM skill learning opportunities for built environment students. The learning opportunities discussed in this paper are archetypes of 21st century skills and featured engagement with diverse cohorts of students, practice-oriented learning, STEM literacy, adaptive thinking and discipline-based core knowledge. The results from 46 student interviews indicate the relevance of 21st century STEM skills for built environment students, and the increased skill set of built environment students involved. The results and outcomes of this research have the capacity to provide industry with built environment graduates who are not only technically skilled but future 21st century STEM work-enabled.

Keywords

21st century skills, construction, employability, graduates, STEM

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Paper ID 013

Integrating Interdisciplinary Thinking And Practice: A Case Study Of A Victorian University In Australia

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Abstract

The value of interdisciplinary approaches to curriculum have been considered successful along multiple fronts; including reducing administrative burden from inter departmental collaboration, providing “intellectual” solutions to problems and breaking academic discipline boundaries. Criticism from industry often focuses on educators not preparing graduates for work in the real world. A major reason underpinning this criticism is that the students are not exposed to the requisite skills to make them work-ready. Despite the pressures to include interdisciplinary approaches from an ethical perspective, putting it into practice is difficult. This paper presents the findings of involving students from three different schools in a Victorian university in Australia: built environment, business and computer science. The project was developed as part of a state government competitive fund where industry, staff and students worked together to support each other and realize mutual benefits. The aim of the study was to develop an approach involving students in a theory-practice model of a real world project by selecting a building within the university as a case study to arm students with real world knowledge focusing on sustainability outcomes. The objective was to assist in preparing students from different disciplines for better workplace experiences, where they can bring in interdisciplinary thinking and practice into their day-day operations. The outcomes for the university, in using this building as a living laboratory, was to capture lessons learned through the process of improving future building developments from a sustainability perspective. Student involvement was successful, but true interdisciplinary engagement was not achieved.

Keywords

built environment, students, inter disciplinary, collaboration, curriculum

Paper ID 016

Early Contractor Involvement (ECI) In Event Planning And Management

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Abstract

Large and mega-events employ traditional procurement approaches, adopting an adversarial stance with contractors/suppliers. These events are often beset with problems with the contractors/suppliers. This study investigates whether early contractor involvement (ECI) is being applied to the procurement processes within the event planning and management industry and to explore the potential benefits and challenges of the application of ECI within that industry. ECI attempts to exploit the contractor/supplier's specialist knowledge and expertise to the benefit the project planning and design process to provide mutual benefits and minimise the drawbacks associated with an adversarial contract. This paper argues that an event is a particular type of project and discusses the potential benefits of ECI to the event planning and management industry. A literature review approach was used to explore the construction and infrastructure industries and the event planning and management industry to determine whether ECI is being utilized to any meaningful degree. Overall the study findings indicate that by adopting ECI the event planning and management industry could expect similar benefits to those observed in the construction and infrastructure industries.

Keywords

ECI, collaboration, event management, project management

(Click on the abstract titles to link directly to the full paper)

Paper ID 017

An Ethnographic Investigation Into A Series Of Incidents On A Large Construction Project

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Abstract

A series of incidents in a short period created cause for concern on a large construction project in the UK (+£500m). Incident investigations are one of the ways to learn about safety failings, so that remedial action can be put into place to avoid a recurrence. The researcher was a member of the H&S department, with the role of a participant observer during the incident investigation period. Data collection included: informal conversations with employees; attending safety and accident investigation meetings; viewing project documents; and attending the safety stand down that occurred. The case study findings revealed that a blame culture restricted information flow on the incidents; and consequently there was a focus on easily observable unsafe acts, and static unsafe conditions, providing a narrow rather than deep perspective. These acts and conditions, such as a lack of compliance with PPE, or a weather condition, were often difficult to manage. For safety understanding the project repeatedly used Heinrich's (1931) seminal work as a foundation. However, this work is arguably outdated as it focuses on accidents on an individual rather than complex socio-technical level.

Keywords

construction, safety, accident investigations, ethnography

Paper ID 018

Preparing Students For A Disruptive Construction Future

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Abstract

Many industries have felt the impact of disruptive change on their profitability and established practices. Examples of disruption have been documented in industries as diverse as transportation, photography, newspapers, retailing, recorded music and computer graphics. The construction industry has mostly avoided large-scale disruption because, in spite of the globalisation evident in mega projects, most construction is locally-based and delivered within a specific national context and regulatory system. This may be about to change. The forces of digitisation, industrialisation and globalisation are combining to generate the potential for disruptive enterprises which will grab market share and shake up existing business models. As academics striving to prepare students to be employment-ready, we need to open their eyes to the potential of the new economy to support new business models that are quite different from traditional construction companies. Students will need to be entrepreneurial in seeking out opportunities and identifying market niches. In two new and developing units/subjects at an Australian university these issues are being raised. Students are challenged to identify markets and market strategies enabled by social enterprises, collaborative systems, the 'Internet of Things' and even 'Brutal Innovation'. Using student feedback and reflective practice, the lessons from the first two offerings of the new units are identified and teased out. In general, students respond well to the challenge of strategic thinking which relates to their future careers. While predicting the future is always fraught with difficulty, not attempting to do so could leave us vulnerable to disruptive change.

Keywords

construction futures, digitisation, disruption, globalisation, industrialisation

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Paper ID 019

Institutional Roles In Effective Statutory Adjudication Implementation

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Abstract
Spearheaded by the Construction Industry Development Board and in conjunction with government support, adjudication and prompt payment regulations have been formulated to address unfair payment practices which have hampered the construction industry in South Africa. Given the complexity, contestability and disputatious nature of the environment in which construction activities are carried out, the implementation of policies is not an easy task. It requires strategies, deliberate plans and adequate institutional support. This paper investigates what measures are needed for effective institutional support and reports on the views of experts on what steps are required for implementation and the roles institutions play in ensuring an effective statutory adjudication process. Data were gathered through qualitative interviews with adjudication experts that have direct interaction and intimate knowledge of the adjudication process in the United Kingdom, Australia, Singapore and Malaysia. The findings identified five institutions that may enhance effective statutory adjudication implementation. However, only two of these five institutions are perceived to be critical and indispensable and without which effective implementation of the adjudication process will most likely not be achieved.

Keywords
implementation, institutional roles, legislation, statutory adjudication

Paper ID 021

Essential Site Coordination Problems In Hong Kong Building Projects

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Abstract
In Hong Kong, it is a common practice for main contractors to divide the projects into work packages by trade and sublet to sub-contractors. The interaction between sub-contractors and main contractors is an important determinant to the success of a project. However, there is an increasing complaint from sub-contractors that they cannot perform to their full capacity because of poor site-coordination by main contractors. This paper aims to identify and categorize the common site coordination problems in Hong Kong Building Projects. Thirty-eight common site-coordination problems were identified through literature and they were classified into six main categories of problems: Construction document; Site management; Site layout; Equipment support; Material support; and Preparation of site area. A questionnaire survey was conducted to analyze the frequency of occurrence (F.I.) and degree of severity (S.I.) of the problems to the projects. The aggregated importance (IMP.I.), taking into account of the frequency of occurrence and degree of severity, of problems on sub-contractors' time performance were ranked. Frequent changes of construction works were found to be the most important site coordination problem. Most of the important problems caused the delay to subcontract works were primarily related to Construction document.

Keywords
site coordination, subcontractor, time performance

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Paper ID 023

Improving Australian Commercial Property Market Forecasting By Mapping Structural Changes In Built Environment

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Abstract
Property market forecasting is an integral element of decision-making. It is critical that property analysts employ a wide - range of models and techniques for property forecasting. These models have one overriding aim of predicting reasonable estimates of key dependent variables (demand, supply, rent, yield, vacancy and net absorption) based on the independent variables of core economic activities. However, a broad- fronted social, economic, technical, political and ecological evolution can throw up sudden, unexpected shocks that result in a possibility of sceptical to unknown risk factors. These structural changes decrease, even eliminate predictability of property market performance. Hence, forecasting beyond econometrics is raised as the research problem in this study. This study follows a qualitative research approach, conducting semi-structured interviews with open-ended questions. The primary data were collected from 22 property stakeholders within Australia. Structural changes framework in the built environment is developed and categorised under PESTEL (Political, Economic, Social, Technological, Environmental, and Legal) factors. This framework was developed theoretically and subjected to empirical validation and improvement. Property conversions, integrated property functions in a single location, 'Give and Take' effect in property markets, NABERS compliance could be seen as emerging structural changes in the Australian commercial property markets. The understanding of the impact on the property market will provide a subjective overlay to improve the econometric forecasts.

Keywords
built environment, commercial property market, forecasting, structural changes

Paper ID 029

Virtual Learning Platforms: Assisting Work Integrated Learning

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Abstract
Work integrated learning (WIL) assists with the assimilation of theory and practice, ultimately producing job ready graduates with the capacity to engage effectively within their chosen work environment. However, for the discipline of construction management (CM), WIL is often impeded by a range of challenges. First, construction sites are considered high risk environments where safety and liability may hinder work place opportunities. Second, large student cohorts combined with distance delivery where impediments of location and the need for an equitable educational experience arise. Furthermore, with regulatory courses, the potential for on-site identification of building code non-compliances (fire safety) further impacts opportunities. This paper presents Stage 2 of a pilot study: Stage 1 involved the preliminary use of a virtual learning platform to simulate an on-site practical experience for students learning construction management curriculum, specifically courses involving building regulation. To understand whether the platform is suitable as a teaching tool and to further enhance the environment and maximise its potential as a CM learning instrument it was also presented, in Stage 2, to a related discipline (health) student cohort who had completed work experience and had a knowledge of fire safety. The intent was to examine realism and replication of a real world environment. Initial qualitative results favour the environment for its realism, immersion and navigation capabilities. Furthermore, it was considered an effective tool for placing theory into context assisting work integration.

Keywords
virtual reality, construction management, work integrated learning

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Abstracts

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Paper ID 030

Improving Buildings Facility Intelligence In Higher Education Precinct: A SocioBIM Approach

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Abstract

Higher education institutions (HEIs) infrastructure asset is a complex and massive investment, with high operational and management cost. The functionality of this infrastructure facility is paramount to the performance and well-being of its users. The effective and efficient operation and management of this facility required adequate knowledge and collaboration of all stakeholders. This study is a preliminary part of a research aim to adopt socioBIM for HE facilities users and facility management (FM) section, to interact with their learning environment and enhance collaborative practice to improve facility intelligence. The study method explores the advancement in building information modelling, decision support systems, and integrator networks based on grounded theory. Conceptually, the adoption of socioBIM reflects an enhancement of users' facility literacy, stakeholder's participation and FM organisational intelligence within HEIs. These will culminate to stakeholder's satisfaction and competitive advantage. Further study is also needful in the efficacy of socioBIM adoption.

Keywords

building information modelling, facility management, higher education, intelligence, learning environment

Paper ID 033

Engineering And Construction Expertise Transfusion At The U.S. Army Corps Of Engineers: A KM Case Study

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Abstract

Knowledge Management (KM) is the collection and transfusion of the organization's critical information, skills, experience, and identity, held by senior individuals, to successor generations for action. A great deal of the technical expertise in the U.S. Army Corps of Engineers (USACE) has been departing through the retirement of the most experienced employees over the last several years and continues to do so today. Without robust technical competency, an organization as large as USACE cannot continue to perform design and construction functions effectively. This research study defines KM, reviews best practices from industry and assesses how USACE is performing at the working level. The research data obtained identified key needs and subsequent recommendations for additional efforts or improvements to existing initiatives. Data was collected through interviews of eight managers at a USACE District Office to make assessments and determine steps to be taken to ensure critical expertise is retained and mission execution continues effectively. This study found that at the working level the current KM program is primarily based on mentoring and informal communities of practice, and not in top-down information systems based approaches. USACE would benefit greatly from reconciling different approaches, eliminating redundant items, and a coordinated approach at all levels of leadership to champion processes that work.

Keywords

knowledge management, U.S. Army Corps of Engineers (USACE), engineering and construction, knowledge transfusion

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Paper ID 035

The Core Functions Of Project Governance

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Abstract

Research in the realm of projects is increasingly turning its focus on governance. Much has been written on the importance of good governance and the clear link between good governance and project success. However, few have delved into delineating the core functions of governance that is central to good governance. In this conceptual paper, we examine existing research ideas and concepts of project governance to develop a framework to add to the knowledge base of this subject. This paper proposes six core functions of project governance. They include (1) determining the objective, (2) determining the ethics, (3) creating the culture, (4) designing and implementing the governance structure, (5) ensuring accountability by management and (6) ensuring compliance. The framework described in this paper can provide guidance to organizations in the development of effective project governance to optimize the management of projects.

Keywords

project governance, functions, values, project success

Paper ID 036

Meeting Changing Industry Expectations From Australian Property Valuation Graduates

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Abstract

The valuation profession faces significant challenges as more valuation processes become automated, and the role of the valuer becomes more one of data handling than an economic analyst. To respond to industry needs, the role of the valuer must change. It follows that there is a need for universities to re-evaluate their existing property curricula, modifying content where necessary, to prepare their graduates better for a changing workforce. Employing a series of focus group discussions with valuation practitioners, this study examined specific industry expectations and provides recommendations to strategically align Australian property curricula with industry expectations in order to maintain the relevance of property education. The study identified personal, technical and business- related skills that are essential for graduates to possess. The roles of the professional bodies, industry/employers and educators to meet the changing demand on the profession are identified. Changes are required to degree programme content in respect of digital technologies and statistical skills. Whilst the universities offer a curriculum that adheres to the accreditation requirements of the professional bodies, there is also a need to incorporate specialised knowledge with set pathways. The need for students to have practical experience is apparent and undertaking placements with assessment that could be credited as part of the degree is recommended. The study highlights the need for a careful analysis of student learning experience to ensure that graduate skills meet the industry expectations, and that graduates themselves are able to adapt to future changes.

Keywords

curriculum, employability skills, property valuation industry, tertiary education

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Paper ID 038

A Method To Measure The Size Of The Australian Built Environment Sector

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Abstract

The building and construction industry, at around 7 percent of Australian gross domestic product, has an important role linking suppliers of materials, machinery, products, finance, and professional and technical services. These two views have been called broad and narrow, with the narrow industry defined as on-site activities of contractors and subcontractors and the broad industry as the supply chain of materials, products and assemblies, and services. The term that arguably best describes the broad industry is the built environment sector. One method that can be used to estimate the contribution of the built environment sector to the economy is through preparation of a satellite account, which reclassifies expenditures available in different industry groupings into a single sector. The System of National Accounts published by the United Nations explains how these are used to provide more detail on sectors that are not adequately represented in the national accounts and gives examples. This paper details how a satellite account for the Australian built environment sector can be compiled from ABS industry data. The paper identifies the sources of the data required and the stages involved in the process of developing a satellite account. Tables at the three and four digit ANZSIC level are presented as examples of what key elements of a satellite account would include.

Keywords

broad construction industry, national accounts, industry data, satellite account

Paper ID 043

An Evidence-Based Interpersonal Competency Assessment Framework (I-CAF) For Construction Education

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Abstract

Communication, conflict management, cultural awareness, leadership, motivation and team working skills are main interpersonal competencies that students at construction management discipline need to build up during their studies at University. It has recently been shown that augmenting students' interpersonal competencies prepare graduates to embrace the novel opportunities and challenges they are facing in the industry. This paper aims to develop a framework to evaluate students' current interpersonal and socio-cultural competencies in the Bachelor of Construction Management and Property (BCMP) Program at the University of New South Wales by addressing the main research question of "What is the deviation of the current level of interpersonal competencies from the targeted level of competencies in BCMP Program?" Two different cohorts of students from the first- and final-year of BCMP program were selected in this study to prevent biases potentially leading to false positives in the data collection phase. A structured questionnaire survey was used for data collection. The results show that first-year students' interpersonal competencies are far behind final-year students. This is because students strongly agreed that their industry experience had helped them to improve their interpersonal skills. First-year students were not able to provide enough evidence for their interpersonal competencies; however, final-year students had provided robust evidence to support their level of the competencies. The identified gaps could be used as guidelines in the development of teaching and learning activities in curriculum design.

Keywords

construction education, interpersonal competencies, student experience

(Click on the abstract titles to link directly to the full paper)

Paper ID 046

Profitability Of Large Commercial Construction Companies In Australia

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Abstract

Increased competitiveness in the Australian building and construction industry has led to reduced profits for builders particularly for tier 1 builders offering essentially undifferentiated offerings. An analysis of the profitability of a sample of large commercial builders based in Victoria have confirmed that net profit margins for these companies are 2 and 3 percentage points of total revenues – wafer thin. The aims of this paper are to characterise the profitability of these commercial builders by examining a range of profitability measures, and to investigate this loss of value across the construction supply chain. The findings indicate that the average net profit margin has nearly halved from 3.2% in 2006 to 1.7% in 2015. Companies with large revenues, those exceeding $500 million annually, exhibit a generally lower profitability than smaller companies. Despite this lower profitability, return for shareholders remains reasonable with an average return on equity of 20% reflecting a shift to higher leverage, lower risk, asset light business model. Like all businesses, construction companies must demonstrate their financial viability by turning a profit and providing a convincing risk-adjusted return to their investors. Empirical evidence suggests that companies reporting low profitability are at increased risk of insolvency. Failure to acknowledge this may lead to serious financial implications for the industry and the economy.

Keywords

commercial builders, profitability, competitiveness

Paper ID 050

Use Of Timber Prefab System For Ensuring Sustainable Residential Housing Supply In New Zealand

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Abstract

New Zealand housing shortage requires effective approaches to address the increasing demand over the next twenty years. Given the current situation of the New Zealand's housing crisis, it is almost impossible to meet that demand by using the traditional methods of construction. Offsite manufacturing system can help improve housing supply capability in New Zealand. With timber being a very sustainable resource and abundant in New Zealand, timber prefab system offers the most economically and environmentally feasible solution to the housing supply challenges in New Zealand. This research aims to investigate a method that New Zealand construction industry can adopt in the offsite manufacturing system at a national scale to improve the residential housing crisis. Ten interviews and ten questionnaires were conducted with clients, designers, prefabricators, and suppliers to identify the risks and required actions in order to achieve successful application of the system. The impacts of several factors on the system such as barriers, enablers and sustainability aspects of using the timber prefab system were studied as part the research objectives. The results reveal the most sustainable method of residential housing supply in the New Zealand within the acceptable risks, productivity and having a secure government investment support.

Keywords

housing crisis, prefab, residential, sustainability, timber

(Click on the abstract titles to link directly to the full paper)

Paper ID 051

Development Of A Collaborative Training Partnership In The New Zealand Construction Industry

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Abstract

In 2015 a first tier New Zealand commercial construction company approached the Department of Construction at Unitec regarding the company's professional development training. The primary aim was to focus on introducing a more collaborative best practice approach in a competitive construction environment to some 300 middle management onsite construction staff over a 4-5 year period. The company was seeking a partnership with an innovative tertiary provider to offer specific professional development expertise, and give effect to the company's strategy for ongoing and accelerated growth. The delivery approach needed to have the greatest possible impact on staff in terms of engagement and knowledge transfer. How was this academic-industry partnership built? In this first part of the research, the philosophical and practical approaches, timelines applied by both parties, the steps of how the partnership was developed from the initial interviews through to the developed successful partnership are described. The preparation and delivery of this practically based, real-time bespoke programme alongside the learnings will be described in later stages of the research in a series of publications.

Keywords

collaboration, building relationships, trust, partnering, organisational learning

Paper ID 053

The Australian Residential Property Market: A Study on Foreign Real Estate Investment

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Abstract

This research focuses on determining the significance of foreign investment in the Australian residential property market subsequent to the Global Financial Crisis 2008. Quantitative models built on secondary data were tested on two residential property markets comprising Metropolitan Melbourne and a key suburb in the Victoria State, Australia. The relationship between the house price performances and various leading offshore and local Australian economic indicators were assessed. As a result of the increasing relevance of globalisation and Asia Pacific private wealth in the Australia, foreign real estate investment has impacted significantly the Melbourne residential property market performance. The result of this study provides a better understanding on the relationship between the Australian residential property market performance and the emerging significance of the foreign investment drivers. A better understanding of these foreign investment determinants will assist policy makers to effectively manage the Australian residential property market without compromising the steady flow of foreign real estate investment. The result of this study is believed to yield findings that can assist the researcher, property market operators and investors in the evaluation of foreign investments in the Australia residential housing market.

Keywords

Australia, residential property, housing markets, foreign real estate investment (FREI), asia pacific private wealth

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Paper ID 054

Leading The Way: Peer To Peer Mentoring To Improve The Student Experience And Adaptability Through Change

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Abstract

Peer to peer mentoring is well established in the literature as providing an effective mechanism to foster student's sense of belonging and to support their resilience and academic progress. This paper reports on a peer mentoring model that was established within a Built Environment School in 2015. The mentoring program was designed to provide peer mentoring support for Chinese students who were articulating into the third year of a Construction Management program delivered at a Melbourne university. The Chinese students had successfully completed two years of a Building Science program at the China University of Mining & Technology (CUMT). To support the Mentees to transition into year three of the Construction Management program three teaching academics from the Construction Management program partnered with their School's Academic Developer. The project team was formed to design and implement a mentoring program that sought to deliver reciprocal learning for local Melbourne based mentors and the newly arrived Chinese mentees. The program was designed to support Mentees to transition into the Construction Management program and living in Melbourne by providing study support and opportunities for social engagement. In this paper the authors reflect on their experiences of designing and implementing the peer mentoring program and report anecdotal evidence which suggests that peer to peer mentoring can provide an effective mechanism through which students are better prepared and supported to deal positively with the process of transition and the many complex challenges this can entail.

Keywords

peer to peer mentoring, international student experience, reciprocal learning

Paper ID 055

Inclusion And Wellbeing For People With Autism And The Role Of Built Environment

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Abstract

Autism Spectrum Conditions are neurological disorders which make inclusion in society very difficult for the affected individuals. The main challenges that people with autism face are related to sensory processing disorders, communication difficulties and restricted repetitive patterns of behaviour. Current methods for integrating people with autism focus primarily on equipping autistic individuals with the tools to tolerate circumstances that they might find uncomfortable in social day-to-day situations. The society's response to accommodating the condition is usually restricted to improving access to selected spaces which often have limited functionality and give the autistic narrow margins for physical and intellectual development. The paper shows the preliminary results of a qualitative meta-analysis of the extant literature relating to societal aspects that need to be taken into account when considering the integration of people with autism. Also, employing the same methodology, the study explores the way in which built environment can have a contribution to the integration of people with autism and the degree to which inclusive physical space represents a positive factor to an autistic individual's subjective wellbeing and quality of life.

Keywords

autism, built environment, inclusion, integration

(Click on the abstract titles to link directly to the full paper)

Paper ID 056

Fostering Student Work Readiness – A University Case Study

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Abstract

Student work readiness relates to the acquisition of relevant skills and knowledge which enable students to make meaningful contributions to industry, and assist them in their transition from student to practitioner. An individual's smooth transition into the workforce translates into higher levels of interactions in their workplace, ensuing in benefits for both the employee and the employer. In the built environment, employees are known to experience high levels of work-related stress, exacerbating the need for built environment professionals to be well prepared for the workforce. While work readiness is typically reserved for graduates who have completed their program of study, there has been a notable increase in built environment undergraduates combining work and study prior to graduation. This trend challenges universities to consider that these students need to be work ready prior to completion of their studies. Research notes that student work readiness can be attained through collaboration between universities, students and industry. This study uses the newly conceptualised work readiness model, known as The Life Buoy model, to explore the ways in which one Australian university collaborates with industry to i.) foster the development of work ready characteristics in built environment students; and, ii.) apply university-based initiatives to underpin the development of work ready characteristics. Analysis of course-related documents classified work readiness initiatives at the university into the eight components of the Life Buoy model, suggesting that it may be a useful framework to guide universities to better work with industry in designing and assessing their work ready initiatives.

Keywords

built environment, industry involvement, student perspective, university initiatives, work readiness

Paper ID 062

BIM Education - Case New Zealand

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Abstract

This article is a first step in a longitudinal research in New Zealand context to identify what impact national education approaches have on uptake of BIM education in individual tertiary institutes. Although BIM and BIM education as research topics are on rise, there is limited research on national approaches and their impact on width and depth of BIM education and through that graduate capabilities and BIM adoption by the industry. Case study approach has been selected to investigate first the challenges encountered by the tertiary institutes, how these can be addressed at national level and in later stages what the impact has been to the width and depth of BIM education and graduate outcomes. Only a limited number of countries such as United Kingdom have introduced national approaches to BIM education. In New Zealand National BIM Education Working Group (NBEWG) was established in December 2014. The group has representatives from eight tertiary institutes who have strong interest in including BIM as part of their programmes. NBEWG promotes integration of BIM into all architectural, engineering and construction programmes in New Zealand by providing national curriculum guidelines and guidance in adopting BIM curriculum. A survey was conducted among the institutes to identify the key challenges encountered in BIM integration. Among these were knowledge and skill gaps among faculty, crowded curricula, and limited time for development work.

Keywords

BIM education, BIM integration, curriculum, graduate capabilities, national approach

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Paper ID 063

Form And Performance: Tall Concrete Structures And Apartment Quality In Melbourne's Residential Towers

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Abstract

Does the structural configuration of tall buildings affect the quality of apartment design? The architecture of tall buildings relies strongly on quantitative inputs. Yields of development, overturning moments, dynamic responses and lift-waiting periods, for instance, are all items that can be readily measured, and the built form of tall buildings has to work within these strict and seemingly unchallengeable constraints. However, these same parameters also impact on the spatial quality of the apartments produced. Four case studies, taken from recent additions to the stock of high rise apartment towers in Melbourne, are used to highlight missed opportunities that follow from an incomplete application of performance-based design, where façade concepts, structural, and construction inputs prevail over those of an overarching spatial integration. The mandate of performance-based design, if driven chiefly by mono-disciplinary concerns, remains necessarily incomplete unless it is verified and corroborated by qualitative methods able to discern broader quality criteria for end-users. A sample of apartments currently under construction in Melbourne's CBD indicates that the emphasis on marketing, structural, and construction demands remains the key driver of current built outcomes, relegating spatial quality and functionality of the dwellings produced to a lower rank of priority. Recently introduced built form controls with public benefit provisions make Melbourne an ideal environment to test, evaluate and discuss within the industry a new range of typologies for residential towers. But such guidelines should start by acknowledging a broader and more evidence-based concept of innovation, design quality and performance in design.

Keywords

performance-based design, tall buildings, built form, apartment space quality, structural typology

Paper ID 064

Identifying Barriers To Retaining Female Professionals In Engineering And Construction Organisations

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Abstract

The construction and engineering industry remains to be one of the most male dominated industries in the world, with between 10 and 25 percent of its employees being female. It is believed that only 62% of women who pursued engineering stayed within the industry. Research suggests that the biggest hurdle the industry needs to overcome is changing the culture within the industry. For engineering and construction organisations gender diversity adds to the opportunity to engage a more diverse range of skills and ideas, with gender diverse organisations being 15% more likely to outperform their respective industry median. It also enables organisations to match the projected more gender diverse client teams and reflect the stakeholders in the communities they serve. The aim of the study is to provide a better understanding of how do we attract and retain female professionals within the construction industry and ensure gender diversity within senior leadership teams. An exploratory qualitative study was conducted with 3 females and 1 male working within the construction and engineering industry. The results suggest that the majority of interviewees joined the construction industry due to the encouragement of a family member and all agreed that having a gender diverse team was important as it creates for more diverse communication with the clients and stakeholders. However the difficult workplace culture and stereo typing still exists particularly around the need to have to work long hours which creates difficulties when trying to balance family and career.

Keywords

construction industry, employee retention, engineering industry, gender diversity

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Paper ID 066

A Comparative Study Of Traditional And Compressed Scheduling On Undergraduate Construction Students' Performance

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Abstract

There is a continual need to modify the way tertiary institutions do business to meet the needs of a changing society. The focus has been on success and retention whereas the new strategy in New Zealand supports wider economic growth and prosperity. There is a need for tertiary organisations to think about existing models and means of delivery, inclusive of new and emerging technologies as well as a continued expectation of the ability for tertiary institutions to deliver content via time and cost efficient means. Traditional scheduling involves concurrent enrolment in numerous courses with less contact time over a 16- week timeframe, whereas compressed scheduling focusses on 2 courses per 8 weeks with more instructional time per week. This paper evaluates the use of compressed scheduling methods for first and second year courses on an undergraduate programme in construction in New Zealand. The quantitative study compares end of course exam results, gender, age enrolment and residency status of 2 first year courses and 3 second year courses for the students from 2011 to 2016. The outcomes are consistent with the literature and support the proposition that a similar student learning experience can be achieved in traditional and compressed courses. The findings of the study suggest that concerns associated with offering courses or providing alternative teaching pedagogies associated with traditional and compressed scheduling are unfounded. Interestingly the females in the study performed better in a compressed schedule as compared to a traditional schedule and warrants further research.

Keywords

adult learning, compressed scheduling, construction student performance, traditional scheduling

Paper ID 069

Consultative Design As An Approach Towards Socially Sustainable Residential Aged Care

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Abstract

Currently residential aged care (RAC) provides a solution to address ageing populations in many developed countries. Demand for RAC is predicted to increase as populations continue to age with the recurrent costs posing an increasing burden on society. The contribution the built environment can play to mitigate this potential burden is becoming increasingly important in the design and construction of RAC facilities. The theories of environmental psychology rationalise the relationship between the physical environment and the individual and impacts work stress/satisfaction. Work stress/satisfaction in RAC facilities has a direct influence on quality of care and can directly affect the residents' quality of life. This paper reports on a two stage study of design influences with the potential to impact upon the care team's work stress/satisfaction in RAC where the benefits of consultative design are indentified. When compared to other facilities in the study the facility utilising a consultative design approach demonstrated more positive and less negative results for the design influences included. The consultative design approach reduced the potential for designers to copy and adapt a previous design, afforded universal ownership of the facility and optimised the building's impact on work stress/satisfaction. The approach formed the basis of an overarching process to ensure the necessary elements of the design influences framework can be appropriately incorporated into the built environment.

Keywords

residential aged care, design, consultative

(Click on the abstract titles to link directly to the full paper)

Paper ID 070

Seasonal Usage Pattern Of Outdoor Spaces In Educational Precincts

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Abstract
Sustainable open spaces in cities can enhance humans' day to day life. Among the determinants of the quality of outdoor environments, high priority is given to ambient climatic conditions. This research is aimed to explore the usage pattern of outdoor spaces in an educational precinct and discover its linkage to thermal conditions. The target population was the users of the main open spaces of an educational precinct selected as the case study in Melbourne, Australia. The data collection methods included field survey (questionnaire and concurrent measurement) and unobtrusive observation. The data obtained was used to understand the characteristics of usage pattern in the three seasons (spring 2014, summer 2015 and autumn 2015). The results indicated the seasonal usage pattern of the precinct and the significance of function of the place on people's presence outdoors. The research findings are expected to inform guidelines on managing outdoor spaces, particularly within university campuses.

Keywords
educational precinct, outdoor thermal comfort, field ns, questionnaire survey, usage pattern

Paper ID 071

The Link Between Facility Maintenance And Work Stress/ Satisfaction In Residential Aged Care

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Abstract
Currently in many developed countries populations are ageing due to a number and combination of circumstances. Residential aged care (RAC) provides a role in addressing the associated need to care for ageing people but the potential for increased demand means RAC providers must look to further efficiencies for sustainability. The care team provides hands on care in RAC and work stress/satisfaction within the care team can be affected by the quality of care and directly impacts the resident's quality of life. The work stress/ satisfaction within the care team can also be affected by the built environment. Appropriate design of the built environment can optimise work stress/satisfaction and this paper will propose that maintenance of that environment can also have an impact. This paper will report on a previous study comprising semi structured interviews with care team members and management representatives from a multi case study comprising a number of RAC facilities. Content analysis was carried out on interview scripts. The study revealed facility maintenance was not only important to preserve an asset and reduce hazards, it also revealed facility maintenance to have a bearing on a number of factors which impacted the care team's work stress/ satisfaction. This paper will suggest that strategies to improve perceived control of facility maintenance may increase a view of self-worth and go towards optimisation of work stress/satisfaction amongst the care team thus promoting a level of social sustainability.

Keywords
residential aged care, built environment, maintenance

Paper ID 073

Application Of RFID In The Prefabricated Timber Industry

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Abstract

RFID (Radio Frequency Identification) has recently gained significant attention in various industries, whereby a common application of the technology is to gather and transmit real-time information related to inventory control and logistics. This paper develops the case for the use of RFID in the prefabricated timber industry by first examining its application in other industries. From there, the paper presents a framework for the adoption and testing of RFID within the prefabricated timber industry as a method to automate inventory control, logistics, and document control, while optimizing construction duration. The paper presents the methodology for field trials designed to determine potential for RFID applications in the prefabricated timber structure supply chain from raw material production to panel fabrication to shipping and onsite logistics and finally through to construction installation. The methodology will be tested in collaboration with industry partners and Forest and Wood Products Australia.

Keywords

construction documents, prefabricated timber, RFID, supply chain, timber

Paper ID 076

Preliminary Investigation Of The Residential Housing Contractors' View Of The Adoption Of BIM Technology

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Abstract

The construction industry increasingly embraces Building Information Models (BIM) in an attempt to enhance work practices and overcome difficulties inherent in complex construction projects. However, widespread use of BIM in small projects, specifically in the residential housing sector, is rarely evident. In an attempt to address BIM's lack of uptake amongst residential housing contractors, a study was initiated to better understand their information/technology needs and the site planning process requirements. The premise is that a construction- orientated BIM tailored to the specific needs of those residential housing contractors can offer better value and possibly contribute to the uptake of BIM technology in that sector. In the current phase of this study, pilot interviews were conducted with housing construction professionals in Victoria, Australia, to investigate some of the existing site and resource management procedures as well as the technology context. The paper reports on selected findings of these pilot interviews particularly the technology support and potential use of BIM in housing projects. The preliminary findings suggest that the technologies actually being used for construction management are quite simple with main focus on managing administrative functions such as procurement rather than undertaking a sophisticated onsite planning process. Furthermore, while the interviewees seem to be positive towards the adoption of new technologies such as BIM, they had concerns about the lack of understanding of BIM technology and the uncertainty about its impact on changing the existing work practices.

Keywords

building information model (BIM), construction management, residential housing, resource planning, victoria

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Paper ID 078

Understanding The Benefits Of Constructing A Residential House With A Heart Of Cold-Formed Steel

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Abstract

Constructing residential houses with cold-formed steel in Australia dates back to the 1940's when there was a shortage of timber for use in the industry. This subsequently led to the formation of the National Association of Steel-Framed Housing (NASH) in 1982 with the objective of promoting the use of cold-formed steel in the construction industry, in particular for application to construction of low-rise residential houses. Over the last few decades, NASH has made significant progress in promoting steel and has led to the inclusion of steel-framed housing in the Building Code of Australia (BCA) and the development of a standard on residential and low-rise steel framing. Conventional detached housing is the largest single form of residential construction in Australia with approximately 120,000 built in 2015. Therefore, the safety, durability, performance and long-term low operational costs over the 50-year design life of a typical residential house are of significance. Constructed residential houses satisfying these requirements would not only translate to significant savings to homeowners personally but also to the nation. This paper discusses the benefits of using cold-formed steel for constructing low-rise residential structures. Based on a full-scale experimental study that was undertaken to assess the overall performance of a brick veneer steel-framed structure, the performance- based requirements of residential houses built of cold-formed steel framing are evaluated and discussed.

Keywords

cold-formed, low-rise, residential structures, steel framing

Paper ID 080

Global Mobility Experience Of Outbound Construction Management Students: The Case Of Western Sydney University

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Abstract

This study focuses on enhancement of job opportunities in international and national markets for construction management students by providing global construction industry experience (IE) placement. There is an increasing trend towards globalisation in the construction industry. This sort of construction training in the international context also improves student's learning experience and global connections. The Australian Government's New Colombo Plan scholarship provides funding for work and study experience for Australian students travelling to the Indo-Pacific region to further their education. All Australian universities welcome significant numbers of inbound international students as well as increasingly encouraging outbound student mobility. This paper reports on the experiences of a number of outbound students who are involved in studying construction management. Through case study research, it was found that international work placements broadened the knowledge of students highlighting similarities and differences when working in an overseas country. Students made useful contacts and were able to improve their employability in both the local and international construction management sector. Their industrial placement was facilitated by the Australian Institute of Building and Hong Kong Institute of Project Managers through professional networks. This study also recommends that this sort of industrial placement and student exchange programs can enhance their communication skills and understanding of the global construction industry practices.

Keywords

australian education, construction industry, global mobility, industrial experience, outbound students

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Paper ID 084

Modelling Green Technology Adoption Based On Sustainable Construction Practices

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Abstract

New digital technologies have the potential to monitor the environmental footprint, mainly Carbon emissions. However, the construction projects slowly adopt such technologies only for monitoring the footprint and other sustainability purposes. Despite the government's policies and external pushes, the adoption decision for sustainability innovations largely depends on different stakeholders' behaviour including developers, consultants, and contractors. This paper presents a novel conceptual model for green technology adoption regarding sustainability in the construction industry. This model is developed based on six main constructs include organizational facilitating conditions, expected performance, expected efforts, innovativeness, optimism, and user performance.

In order to develop the model, factors affecting the green technology adoption process are identified, a questionnaire is designed, and an empirical investigation is conducted to collect data from construction companies. Regression analysis is utilized to analyse the data using SPSS. The findings show the importance of a series of factors influencing sustainable technology adoption. Based on the extensive review on the relevant literature, few empirical studies have been conducted to examine the proposed constructs sustainable technology. The results are also providing a guidance to broaden understanding of users' adoption behaviour within this context and thereby increasing the chances for successful adoption of sustainable technology and develop activity-level.

Keywords

construction projects, green building, sustainability, technology adoption model

Paper ID 085

Towards Managing Iterative Changes In BIM Collaboration Workflows

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Abstract

Collaboration on Building Information Models (BIMs) requires iterative and distributed processes that make maximum reuse of the information being exchanged directly between models in a platform independent model collaboration environment. As the information in a BIM grows during an iterative design and production process and even beyond into maintenance, a critical issue is how to manage the iterative changes because of the collaboration operations and workflows that involve various project participants and heterogeneous applications. This paper highlights the overall problem of managing iterative changes in BIMs and discusses various issues and challenges involved in controlling the collaboration transactions on a BIM data repository in a multi-model collaboration environment. This positional paper describes that model matching and comparison strategies are the keys to solve the problem of iterative change management, which may have better solutions in other knowledge domain such as software engineering. The future research is exploring Software Source Control (SSC) strategies to devise a signature-based model comparison approach for IFC models that can lead to potential solutions for effective management of collaboration operations with BIMs.

Keywords

BIM, IFC, model server, model comparison

(Click on the abstract titles to link directly to the full paper)

Paper ID 086

Individual Risk Attitudes In Postgraduate Risk Management Education

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Abstract

Risk management is important for contemporary construction organisations, and is a vital constituent of project management education. Before learning about the processes of systematic risk management, construction and project management students need to better understand risk concepts and their own attitudes towards risk. Risk is a psycho-social construct experienced and perceived by individuals. In the Risk in Construction subject offered in the Master of Construction Management programme at the University of Melbourne, students were first invited to respond to a simple questionnaire that measured their own risk attitudes from a task, team and individual risk perspective. This self-knowledge discovery was then applied in their subsequent individual and group assignment work for the subject. The risk profiles were also used in a novel approach to assignment group formation. Students valued the opportunity to explore the alignment between formal project risk management and their own risk attitudes, and used their newly-found understanding in other management-related subjects. Future research will explore cultural and gender influences in these student journeys of selfunderstanding.

Keywords

assignment groups, construction management, education, risk management

Paper ID 089

Modelling User Perception Of Online Visualisation In Real Estate Marketplaces

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Abstract

Increased internet penetration rate has made internet marketing an integral part of real estate industry. This may result in an inefficient process for the buyers and sellers due to the need for physical inspection. The aim of this study is to present key factors influencing the users' decision to use a web-based technology for real estate purposes. This is an ongoing study including two phases: developing a framework based on a case study, and conducting a survey to measure customer perception on incorporating online visualization techniques. The paper presents the result of the first phase evaluating real estate marketing platforms as case studies in Pakistan and Australia. While the initial results show that physical inspections are still required before deciding on property transaction, it was found that the number of inspections can be reduced by incorporating a 3D model of the property to the listing platform. In addition, it was observed that clarity of search results and provision of a 3D model are some of the key factors influencing the user preference to use the website again. This reinforces the idea that advanced visualization techniques can improve the current reliability issues faced by customers and may also streamline the transactions. This study will be extended by conducting the designed survey in two target countries one a developed country and the other one a developing country to compare the most popular features to international customers.

Keywords

online marketing, digital real estate, smart technology, virtual reality

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Paper ID 093

Value Management In Architectural Education: Case Projects On Re-Purposing Heritage Sites

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Abstract

Architects are best positioned to embrace Value Management (VM) at early project stages. VM helps to maximise project outcomes not simply in terms of cost-benefit but in the larger picture and long-term vision. Project objective identification is the process of guiding design teams to achieve common goals and maximise project values through an ideation process. Five heritage sites are used to investigate value management uptake in a traditional design studio context. Findings show that VM assists on the value creation and value capture process maximizing project lifecycle outcomes. Although a structured technique, VM complements ideation and creative processes traditionally applied in design studios providing thus an evaluation framework for architects. VM was also seen as an effective technique to effectively engage with clients.

Keywords

value management, ideation, creative thinking, design

Paper ID 094

BIM Integration In Architecture Studios: The G-Lab Milano

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Abstract

Does Building Information Modeling (BIM) hinder creativity and design thinking? Can BIM be embedded into Master architecture studios at early project conceptual stages? These two questions were addressed through experiences of running architectural graduate studios at Politecnico di Milano, Italy with an embedded BIM component. This paper is reflective in nature and discussion is based upon five years of anecdotal experience, thus providing in-depth discussion before diving into a quantitative followup study. A single case study is used to elaborate on the interactions of a manual design (including CAD) versus BIM iterations. The findings show that BIM does not hinder creativity but promotes a more rigorous thought process as ideas are demonstrated and tested. BIM is rapidly moving as a cloud-based application opening opportunities for iterative connected design and this is expected close the gap between creative conceptualisation and rational project stages, significantly if not fully. An open discussions on BIM implementation in architecture education is presented including the integration of BIM into the teaching curricula.

Keywords

architecture, creativity, ideation, rational feedback, cloud-BIM

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Paper ID 098

Working In The Residential Sector: Anecdotes Of A 'Boss Lady' On-Site

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Abstract

The Australian Construction Industry faces looming labour shortages, which some argue can be addressed by employing more women. Yet the proportion of females working in the industry is declining. The challenges that women face in the commercial building sector have been well- documented. However, much less is known about female construction professionals working in the residential sector. This exploratory research presents a single case study of the lived experience of a mid-career female Construction Manager (CM) who has been working in the residential sector for over 15 years. Data were collected written self- reflections and semi-structured interviews. Thematic analysis revealed the defining characteristics of the Construction Manager's experience and the findings were then compared with the existing construction literature. There was an over-riding perception of sexism and the need to perform better than men in order to earn respect. The importance of having pre- planned strategies to manage gendered expectations emerged. The analysis revealed that the CM framed her many challenges as an individual "private trouble" to be endured and overcome, rather than structural barriers, which constitute a "public issue", requiring an industry-level shift. Recommendations are made to encourage Industry and policy makers to initiate the structural changes necessary to include women in the workforce. Suggestions are also made for Built Environment educators to support structural changes in the workplace by working with industry and professional bodies; and through incorporating this issue in the curriculum to raise student awareness and explore innovative solutions for the future with young emerging construction professionals.

Keywords

construction manager, gender, residential sector, women

Paper ID 099

Structural Equation Model Of Strategies For Successful Stakeholder Management In PPPs

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Abstract

Public Private Partnerships (PPPs) have become an increasingly popular choice for the delivery of infrastructure facilities in the recent years. With the involvement of multiple numbers of stakeholders in a PPP project, stakeholder management (SM) plays a decisive role in project success. However, many issues in the recent PPP projects in Australia as well as around the world can be directly or indirectly related to the SM concerns of a project. The correct selection of SM strategies and a proper framework will help to solve most of the current SM related issues in PPP projects. In an attempt to understand these pre-emptive SM strategies and their links to SM management related issues in PPP projects, a hierarchical structural model was established. Subsequently, by employing the structural equation modelling technique, the model adapts a total of 34 SM strategies and 12 SM related issues. Based on the survey data collected across the industry experts who have exposure to a various number of PPP projects in Australia the results of the model confirmed that the SE is a key to minimise the SM related issues in the PPP projects. Further, interestingly SMO and SM related issues has a positive significant relationship suggesting that more the SMO might lead to more issues. Finally, the relationships between the main tasks of SM were confirmed via the model. With a clear understanding of the significance of these SM strategies in PPP projects the findings could potentially contribute to the PPP project success.

Keywords

issues, public private partnerships, SM, strategies and structural equation modelling

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Paper ID 101

Role Of Regulatory Framework For Supporting Construction Industry In India

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Abstract

The role of the construction industry has played a significant role in supporting the steady growth of Indian economy over the past. Second only to agriculture, the construction industry constitutes 6% of GDP. With the rapid rate of urbanisation and increasing liberalisation of the economy, the growth in the housing market is also substantial. Under a single national scheme “Pradhan Mantri Gramin Awaas Yojana (PMGAY)” the Government of India is committing to building over 30 million homes by 2022. To support the growth in the construction industry, an appropriate regulatory framework is crucial. India is a country with a population of 1.3 billion, residing in 29 States and seven Union territories. Total GDP is over two trillion US dollars, growing at more than 7% per annum. No single regulatory framework is currently in place. There is a high degree of fragmentation of policies, which therefore does not support standardised practices or quality in construction.

There are many causes of poor construction quality India. Resolving these causes requires an extensive national effort. That effort is made unnecessarily more difficulty by the lack of common national regulations or standards.

The University of Melbourne is engaged in a Smart Villages research project to build capacity in construction management in Assam, one of the North-eastern states of India. This research will report on a comparative analysis between the regulatory frameworks of Australia and India. Based on the comparative reviews of the regulatory policies, and comparing the scale and operating environments of both countries, the presentation will highlight regulatory gaps to be filled, and enforcement practices to be created, if India is to overcome the challenges described above.

Keywords

construction, regulations, india, building

Paper ID 102

A Change Management Perspective On The Implementation Of BIM For FM

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Abstract

Change plays a significant role in the implementation of any building information modelling (BIM) initiative. For owners transitioning from a traditional facilities management (FM) approach to one supported by BIM, change management is required due to the technological and organisational transformation involved. Yet little is known about the characteristics of how that change is managed. Based on a case study, this paper provides an example of a change strategy employed by a university client/owner during the implementation of BIM-FM integration on a new building project. It describes a ‘niche project’ change management strategy and its key attributes during the early stages of an owner transitioning to BIM-FM integration.

Keywords

building information modelling, facilities management, change management

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Paper ID 103

Tall Building Form Optimisation: Designing for Urban Resilience

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Abstract
The paper presents a performance-based design method that combines building and urban objectives for the control of winds impacting on tall buildings at the pedestrian, podium and upper levels. The performancebased method accounts for wind flow and wind load in a form optimization technique that considers a variety of criteria defining urban microclimates, defined by high-density, multi-level building forms subject to acute variations in seasonal wind conditions. The approach is based on the theoretical foundations of 'designing for urban resilience; and highlights the different objectives of this approach relative to existing (tall) building design standards and urban city planning guidelines.

Keywords
performance-based design, form optimization, urban resilience

Paper ID 106

Significance Of Culture And Education In Developing Smart Villages In India

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Abstract
Over 69% of Indian population that live across 0.6 million villages represent a significant part of Indian Society. However, little has been planned and invested in villages as compared to the urban areas. The fact that villages share only a little less than a quarter of the India's GDP tells us about the lost potential. The sheer numbers are enough to hold as a good argument for planning and dedicated research and investment in this sector. In an effort to empower these rural communities for living with their potentials and contributing positively to the national economy, the creation of the smart villages would not only affect the future of settlements but also force significant changes in the lifestyle in the rural areas. Investigating the elements of the character of the villages and sense of belongingness to the community, this research aims to develop a framework for providing necessary education on the impacts on the vernacular characters of the place while promoting development, sustainability and affordability in the hills of Assam. The next few pages would briefly explain the essential and interdependent components that are part of a smart village, before elaborating on a typical rural house and its cultural elements that are architecturally displayed in the layout and use of spaces by the occupants. This research is only part of understanding the role and significance of culture and community as essential factors for developing rural and remote areas that would be socially acceptable.

Keywords
components, cultural value, education, house, smart villages

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Paper ID 107

Prefabrication Technique For Low Cost Housing In Assam

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Abstract
The housing Pattern of North Eastern part of India can be categorized in three different types. The old primitive type of housing known as Assam type houses are predominant in the North-eastern region. These are mostly residential houses maximum upto single story. The house is generally made of timber. The vertical Post, roofing are made of wood, bamboo supported biomass wall cladding for wall panels are used. With the passage of time this unique method of construction gained importance and newer technology with the use of brick masonry, R.C coloumn and timber roof are being adopted by the local people. This transfer of technology from generation after generation led to the present housing scenario which can be termed as non engineered houses mainly modular and non modular type of construction and R.C.C structures. These non engineered houses have very low vulnerability and poor comfort. The construction type for these houses are dependent on weathering conditions. Therefore there is an urgent need to provide housing with basic facilities for improving living standards without disturbing the natural resources and creating employment opportunities for the local communities. This research aims to investigate the modernisation of the physical structure, construction processes, use of prefabricated components, composite materials, affordability and sustainability of the housing types in Assam.

Keywords
prefabrication, india, smart villages, rural, building

Paper ID 108

A Framework For Successful Implementation Of Green Supply Chain Management (GSCM) In Construction Organisations

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Abstract
Green Supply Chain Management (GSCM) is considered as one of the main efforts, which aim to integrate environmental parameters within the supply chain management. It helps to reduce carbon emissions and improve environmental performances of organisations. As a result of that GSCM has been integrated into the strategic planning of most of the construction organisations. As in case of all radical innovations, barriers or challenges are also expected to be present in the implementation process of GSCM in construction organisations. Hence, it is essential for organisations to identify any barriers that they may face and establish approaches for successful implementation of GSCM in their organisations. Thus, this research aims to develop a conceptual framework by conducting a comprehensive literature review on GSCM practices to address the above-mentioned issues. According to the research findings, the main barriers to implementing GSCM can be categorised into five main categories such as technology, knowledge, finances, outsourcing and management. Furthermore, the strategies to improve GSCM practices in construction organisations include: commitment of top management; changes in existing policies and technologies; improve the awareness of environmental issues; training and education; and implementation of efficient materials and waste management systems. The suggested framework can be applied in construction organisations to identify the key components of GSCM and self-assessment of barriers and strategies to successfully implement GSCM in construction organisations.

Keywords
barriers, construction organisations, green supply chain management (GSCM), strategies

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Paper ID 109

A Framework For Property Developers To Survive In A Recession

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Abstract
Recession is considered as a major threat to the economy as it slows down the economic activities. The property development sector is extremely responsive to these economic conditions. Thus, it is crucial to understand causes, effects and strategies for property developers to survive in a recession without any ill effects. Thus, this research aimed to develop a framework for property developers to identify appropriate survival strategies in a recession. A comprehensive literature review was conducted in this research to achieve the above mentioned aim. The results of this study indicated that recession prompts negative impacts on the property development sector resulting in unemployment, low demand, low production, low revenue, decline in resources and high level of competition. According to the results, the survival strategies were classified into short-term and long-term strategies. The short term strategies include: implementing management tactics; cut down of operating costs; keeping financing lines set up; timely repayment of debts; setting vital new objectives for the future; undertaking short-term developments; specialisation in favoured market; and renegotiating contracts. The long-term strategies include: retrenchment; restructuring; investment; and ambidextrous strategies. Similarly, attention should be paid to predict any changes in the economic environment that can influence property development activities and it is necessary to carefully evaluate the investment activities to increase sales, profits and market shares of property developers. Preparing for a crisis is doubtlessly the ideal approach as it can facilitate both survival and growth. Thus, the property developers can implement these suggested strategies in their businesses to enhance their practices.

Keywords
effects, property development, recession, strategies

Paper ID 110

"If You Cannot Measure It, You Cannot Control It" - Buildability And Performance-Based Appraisal

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Abstract
Buildability has been a perennial issue in the Architecture, Engineering and Construction (AEC) industry, with advocates arguing for positive benefits related to cost, time, quality and safety in project development. Evidently, buildability has been seen to offer broader industry gains and efficiencies, and its assessment has been encouraged as a criterion in the regulatory approval process of some countries. If buildability offers positive outcomes in project development, how can these be introduced, measured and assessed in the project development process? In the absence of mandated buildability appraisal systems, does the industry develop its market mechanism to leverage the gains that its consideration offers? Detailed coverage is systematically reviewed with the aim to identify the current trends in buildability. Based on a comparative analysis of existing assessment models of buildability, this paper reviews the suitability of this model, by highlighting the potential difficulties of its adoption, against the current deregulated and highly performance-based context of the Australian construction industry. The outcome of this paper is to provide a research methodology to develop a buildability assessment tool for Australia.

Keywords
australia, buildability, construction practice, deregulation, performance-based design

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Paper ID 114

An Investigation Of Digital And Online Information Technology Adoption In Property Management

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Abstract

Recently, driven by the pressure to improve efficiency and sharing information, there is growing interest to introduce digital technologies into the property management market. Emerging digital information technologies are changing the way of managing rent, purchase and sale of properties as well as real estates' business. The technology covers a wide range of items such as professional web-based platforms and social media offering rich information to customers. Despite the proven advantages of sharing information through visualization and query making options, and drilling into the digital documents, the factors influencing the acceptance of such technologies by customers and real estates has not been fully studied. This paper aims to develop an innovative technology acceptance model identifying influential key factors of acceptance of the technologies by both customers and real estate agencies. A survey of 50 real estates' staff members and their customers is conducted.

The results indicate that the number of agencies and customers tending to use information technology and online data bases as their main resources is increasing. The results of the survey show that real state agencies believe that the use of online information technologies enhances the number of customers as increases the level of visibility and accessibility of their services. Customers believe that factors such as better delivering and on-time services are main contributors of making the right choice to rent or purchase properties. Increased speed of transactions, reduced time for finding an appropriate property and provided capability of comparison with similar properties are found to be main advantages of these online information technologies.

The results of the survey also show that the main problems of technology adoption from real estate's point of view are lack of real estate agents' knowledge and shortage of specialists. In addition, the most significant barriers of technology adoption in the real estate industry are lack of trust to companies' websites and also lack of knowledge for users.

Keywords

digital information technology, property management, real estate

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Paper ID 116

Critical Review Of Factors Affecting The Quality Of Build In Residential Volume Building

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Abstract

Consumer satisfaction is no longer a novel concept in terms of quality assurance and is paramount for business survival, success, and economic prosperity. It now forms an integral part of most business practices. The ability of the construction industry to deliver a quality service is critical for sustained consumer confidence and a healthy economic performance. In recent years, consumer satisfaction has been shown to form a key driver for continuous business improvement particularly in the residential volume building sector. This is a working paper and is part of a major review on the ability of the volume building residential industry in te state of Victoria to deliver quality services to their consumers. The outcomes of this on-going research project will provide both academics and practitioners with valuable support in this direction. This paper presents the initial findings based upon one of the author's experience in the volume building sector. The findings suggest that there are several factors that directly and indirectly influence the housing quality in Victoria, these include: demand and supply of housing; marketing; sales through to site completion; building inspections and audits; supply chain relationships; competency of site supervisors; project planning and control; after sales service within which the residential sector operates. These factors have varying influences on each other, and are therefore interrelated and cannot be treated in isolation.

Keywords

consumer satisfaction, quality, residential building, volume builders

Paper ID 118

Electrical And Mechanical Safety In Repair, Maintenance, Alteration And Addition (RMAA) Works

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Abstract

In Hong Kong, the repair, maintenance, alteration and addition (RMAA) sector becomes a more significant component of the construction industry with the implementation of the Mandatory Building Inspection Scheme (MBIS) by the Hong Kong SAR Government. Around 2,000 buildings would be targeted each year under the MBIS and it is expected that the volume of RMAA works will continue to increase. The public consultation paper issued by the then Housing, Planning and Lands Bureau (2006) indicates that the number of private buildings over 30 years' old in Hong Kong will rise to 22,000 by 2018. The condition of buildings becomes dilapidated as building age increases. Electrical and Mechanical (E&M) installations play an important role and involve a large number of practitioners. Among different types of accident, fall of persons from height and electrocution are the top two E&M works' killers. The safety of E&M work has not received sufficient attention. Only a very limited amount of safety research on E&M works especially in the RMAA sector has taken place. This study aims to reveal the causes of accidents on E&M works in the RMAA sector and provide recommendations to improve the safety and health of E&M practitioners. The significance of the study lies in providing a thorough E&M accident analysis in the RMAA sector, for the first time. A systematic approach with multidisciplinary inputs will lead to the identification of the causes of accidents and the formulation of holistic and practical measures for preventing accidents on E&M related RMAA works.

Keywords

electrical and mechanical, safety, construction industry, repair and maintenance, bayesian network approach

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Paper ID 122

Identifying The Regional Segmentation Of Retirement Villages In Four Australian States From The Market Perspective

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Abstract

The retirement villages have become increasingly important for the community, practitioners and policy-makers across Australia over the decades. As one type of purpose-built housing, the retirement villages contain the heterogeneity throughout the designs, locations, implemented facilities, and services. However, relatively little attention has to-date been placed on identifying the regional heterogeneity of retirement villages across Australia. Nevertheless, little research has addressed whether the regional heterogeneity of retirement villages leads to segmentations from the market perspective. The purpose of this research is to investigate the regional heterogeneity and the associated market segmentations of the retirement villages across four Australian states. This research combined a content analysis and a market analysis of the elements of the retirement villages. The data relating to retirement villages in the four observing Australian states were collected from a specialised website for retirement villages. A hedonic pricing model was used where the price distributions relating to the elements were estimated. From the aggregate perspective, the design elements contribute to the price significantly; the elements of the facilities and services are less related to the price relatively; and the location and size of the villages have the weakest impacts on the price. However, the regional results confirmed the segmented market for the retirement villages across the four Australian states. The outcomes provide stakeholders with regional market information to assist in guiding the future direction of the retirement village industry and the local governments.

Keywords

retirement village, price, regional segmentation, hedonic analysis, australia

Paper ID 125

Exploring The Implications Of Urban Vulnerability To Incidents Of Building Collapse For Construction Safety Research

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Abstract

Engineers and architects have not yet developed a model for predicting when and where a building may collapse. However, the odds are high that any such incident(s) may occur in an urban setting, particularly in a developing country. This review bemoans on the public safety implications of the rising urban vulnerability to incidents of building collapse for our ever-urbanising world. It acknowledges the proactive turn that construction and building safety research has taken– i.e. the shift from, hitherto, ex-post facto analysis of trigger events to identifying and neutralising organisational preconditions that create vulnerability for failures to occur. It, nevertheless, contends that the questions that urban vulnerability to building collapse incidents raise, such as what web of forces are at play, why is it predominant in developing in contrast to advanced countries and their corollaries, are beyond the current scope of causes of vulnerability for construction failures research. It calls for more attention to the under-researched role that the broader socio-politicaleconomic factors that influence construction processes and practices play in generating vulnerability for collapse incidents. Such endeavour, it is envisaged, could confer useful insights to affect broader social, regulatory and policy measures to address the phenomenon.

Keywords

building collapse/failures, construction accidents, urbanisation, safety culture, socio-political-economic factors

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Paper ID 128

Rural Construction Management For Developing Economies: Implications For Professional Education—The Case Of Assam

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Abstract

The authors are engaged in a three-year project, funded by the State of Assam, India, to develop new postgraduate qualification in construction management for Assam, and to research housing and infrastructure strategies aimed at improving rural life. This inter-cultural collaboration mirrors a common arrangement in international development assistance in which an institution from the Global North is invited to assist an institution from the Global South. However, the historical relationships between the North and South, and the way in which they play out in such arrangements has been critiqued from multiple perspectives. The North-South divide is rooted in colonial history, is based on a privileging of the North over/against the South, and works to place the South at a perpetual disadvantage. These privileges are often replicated in the historical-given curricula of postcolonial universities. It is important in undertaking this work for Assam that these historical influences be analysed and critiqued, in order to decolonise the curriculum. This paper outlines the process by which the Project seeks to identify Assamese problems and interests, source useful examples globally, and collect and synthesise them to create products that are tailored to Assam. The key findings: standard professional education is Eurocentric and does not relate to the construction needs of Assam's population, helps drive rural-urban and South-North brain drain. Nascent models are available to counter these tendencies, and can be studied to inform Assam-centric construction management education.

Keywords

construction management, developing economies, professional education, rural development

Paper ID 129

Factors Affecting Construction Students' Satisfaction With Grades In Design Courses

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Abstract

The construction and built environment sector is dynamic. It is made up of professionals who are knowledgeable about design, planning, construction and cost estimation. Design is one of several courses undertaken by construction students. Assessing design drawings is demanding for tutors as the assessment criteria need careful consideration. Assessment resultsmay encourage or discourage students. Their morale may be affected if they feel their efforts have not been rewarded. Achieving a balance between the tutors' decisions and students' satisfaction is therefore important. This research sought to identify factors affecting students' satisfaction with grades in design courses. The study was undertaken among year 3 and 4 architecture students in a Nigerian university. One hundred and twenty students were invited to reply to an online questionnaire. Their responses revealed that most of them were not satisfied with their tutors. They felt that marking was inconsistent. This study identified a range of ways students felt assessment could be improved. Chief amongst these was a suggestion that the same tutors assessed the work of all students (rather than for several tutors to be involved). Based on these issues, the paper suggests ways to balance tutors' assessments and students' satisfaction.

Keywords

design courses, grades, students' satisfaction, tutors

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Paper ID 130

The Impact Of Individual Beliefs And Expectations On BIM Adoption In The AEC Industry

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Abstract

The use of Building Information Modelling (BIM) in the construction industry has been growing steadily during the last decade, yet there is a continues resistance to its adoption, due to some users' unawareness of BIM benefits. BIM adoption is associated with an individual's willingness towards using it which is driven by individual beliefs and expectations of BIM use consequences. Technology Acceptance Model (TAM) identified perceived usefulness (PE) and perceived ease of use PEOU as variables to inform us with user's mind-set and intentions towards the use of technology. This research proposes a conceptual framework for exploring and measuring individual willingness level for adopting BIM, based on individual beliefs and expectations of BIM use consequences in construction industry. The research conducted literature review on technology acceptance and use theories from IS mainstream to identify the individual beliefs and expectations variables, then conducted a literature review on case studies researches that directly applied TAM, to contextualize the variables into BIM in construction environment. The research outcome identified the individual willingness constructs to accept and use BIM: performance expectancy, effort expectancy, social conditions, facilitating conditions, and attitude towards using.

Keywords

building information modelling, BIM adoption, individual believes and expectations, technology acceptance model, user satisfaction

Paper ID 131

Training Transfer As The Result Of Rational Decision-Making Process

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Abstract

Employee training is delivered as a part of most human resource development programs because organizations expect training courses will enhance their employees' performance. However, training may not lead to improved work performance if training transfer does not occur. The lack of training transfer in practice has long been considered as a critical problem. Also, previous theoretical models of training transfer cannot fully explain this phenomenon. As an attempt to solve the training transfer problem, this paper provides a literature review on training transfer and proposes a conceptual model grounded on the Theory of Planned Behaviour.

Keywords

training transfer, models of training transfer, the theory of planned behaviour, literature review

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Paper ID 132

Appraising Constructive Alignment In A Construction Management Programme

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Abstract

Construction Management (CM) programmes generally build on principles in traditional science and social-science disciplines, creatively applied to the construction sector. In the last two decades, there has been significant growth in the number of universities in Australia and UK, offering construction management programmes. Despite these trend, there has been dearth of studies that investigate the alignment of the curriculum content with assessment requirements in construction management subjects. This study appraises the issues pertaining to constructive alignment in construction management programmes delivered in the higher education sector. This work provides an ethnographic insight on the perceived benefits of Constructive Alignment in relation to academic performance, student experience, and student-satisfaction in the UK. Future work will compare outcomes in constructively-aligned courses in other academic institution. This work also suggest best practices for implementing constructive-alignment in the delivery of built environment courses.

Keywords

constructive-alignment, construction-management, ethnography, higher-education

Paper ID 134

Improving The Student Experience With Learning Analytics In Construction Project Management Courses

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Abstract

Learning analytics is an emerging field that has been gaining momentum in higher education. Learning analytics is the analysis and reporting of learner related data. Research has examined the benefits of learning analytics in higher education but there has been limited research conducted about the impact of showing students their own learning data. The aim of this study was to provide students with their own learner data, obtain feedback about the usefulness of this information and investigate if providing learning data leads to an increase in self-efficacy and self-reflection. The sample consisted of 78 students studying construction management, project management, and property and valuation at RMIT University. Students were provided with weekly learner reports that included data about their behaviour in a learning management system, their level of interaction in lectures and their performance on assessments. A suggested target was provided toward an individualised behaviour goal, as well as comparison with both the contemporary class average and previous class averages. Students completed measures of self-efficacy and self-reflection pre and post intervention and feedback about the reports was obtained through surveys and a focus group. Results showed no significant change in self-efficacy and self-reflection, however, students reported finding the learning analytics reports helpful, believed it helped them reflect on their own learning and wanted to see more analytics in other subjects. Results support the use of learning analytics in the classroom and suggest that they may enhance the student experience.

Keywords

learning analytics, higher education, construction project management

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Paper ID 139

Overview And Analysis Of Digital Technologies For Construction Safety Management

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Abstract

Digital technologies are increasingly used to support safety management in the construction industry. Previous efforts were made to identify digital technologies for safety in the construction industry. However, limited research has been done to conceptualize the roles played by digital technologies in safety management and accident prevention. This paper surveys state-of-the-art research between 2000 and 2016 in order to categorize digital technologies for construction safety, identify research trend, and analyse their roles in accident prevention. The research employs a systematic process to review the existing literature on digital technologies in the area of construction safety. Five academic databases, Science Direct, Taylor & Francis, the ASCE Library, Engineering village, and Web of Science, were selected for the survey due to the comprehensive coverage of relevant academic papers. The survey identified 15 digital technologies: real-time location system and proximity warning, building information modelling, augmented reality, virtual reality, game technology, e-safetymanagement-system, case-based reasoning, rule-based reasoning, motion sensor, action/object recognition, laser scanning, physiological status monitoring, virtual prototyping, geographical information system, and ubiquitous sensor network. Three emerging safety functions claimed and/or promoted by DTs were discussed: enhanced safety planning, real-time hazard management, and safety knowledge engineering. It is concluded that DTs have great potential to improve safety performance by engineering resilience and adaptiveness at the individual level, while how DTs embody safety values and how safety values in turn influence the adoption of DTs remain an open question.

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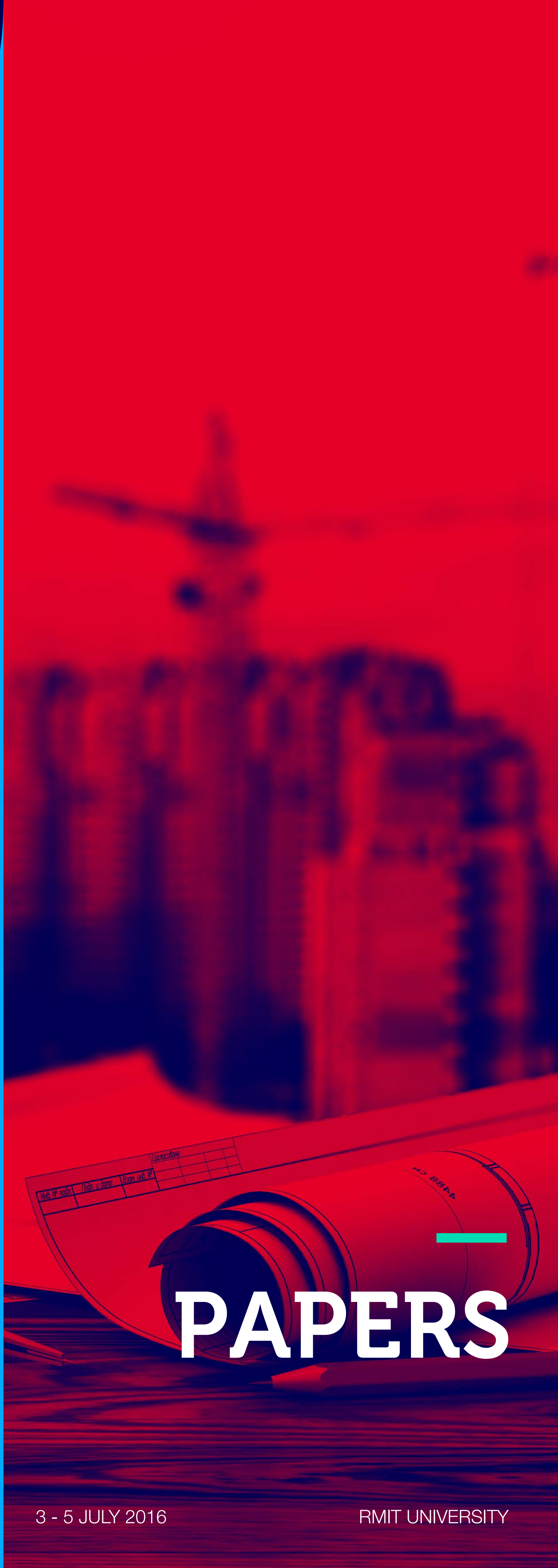
Keywords
accident prevention, construction safety, digital technology



PAPERS

Resetting the compass: An immersive intervention to develop abilities in Construction Management

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ABSTRACT

Students' post-intervention perceptions of an event provide insight relative to their understanding and appreciation of the intervention, as well as the impact thereof.

Experience and anecdotal evidence indicate that Honours students experience challenges in terms of completing the academic year.

The purpose of the study reported on is to determine the impact of a one-day team building event on participants directed at, inter alia, developing their ability to manage themselves, work as a team, and interface with each other, and their ability to strategise, plan, evolve tactics, and take action, based upon a self-administered questionnaire survey conducted in a South African university. The students were surveyed after the completion of the event.

The salient findings include - the team building activities impacted on participants in many ways, contributed to an enhancement of their ability to strategise, plan, evolve tactics, and take action, and participants enjoyed and benefited from the team building activities.

It can be concluded that the one-day team building event had the desired impact in terms of the development of participants' ability to manage themselves, work as a team, and interface with each other, and their ability to strategise, plan, evolve tactics, and take action.

It is recommended that the one-day team building event continue to be staged at the beginning of the Honours year, and that the post-event research be conducted on an annual basis.

Keywords: actions, construction management, students, survey, team building.

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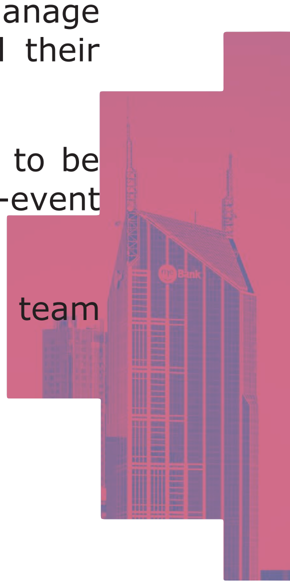

INTRODUCTION

The traditional academic programme within the Nelson Mandela Metropolitan University (NMMU) Department of Construction Management has in recent years struggled to actively engage with students to prepare them adequately for the rigours of the honours year of study. An inability to manage themselves, strategise, plan, evolve tactics, and take action, which in turn should have contributed to their ability to study, undertake assignments, projects, and especially complete the treatise research project, have negatively impacted on the successful completion of the honours year of study.

Furthermore, these skills and attributes should have contributed to their ability to respond during employment interviews, effectively integrating them into the construction industry upon employment, and to fulfil a form of management function in the industry, which from industry liaison interaction was seen to be a weakness in the graduates being produced.

Given the aforementioned, and the Department of Construction Management's focus on 'lecturing and learning' research in addition to general assessment of courses, programmes, and related interventions, a survey was conducted among participants of a one-day team building event which was introduced at the commencement of the Honours year of study. The objective was to determine the impact on their ability to:

- manage themselves, work as a team, and interface with each other, and
- strategise, plan, evolve tactics, and take action that would lead to their team winning the 'race'.

The aim of the research being to better prepare the students for the challenges of the Honours curriculum, specifically the intensity of the treatise research, as well as for workplace placement upon graduation.

REVIEW OF THE LITERATURE

"Construction management programmes need to empower graduates to manage the business of construction" (Smallwood, 2006), which requires that the learning environment develop their ability to manage themselves, work as a team, and interface with each other. In addition, their ability to strategise, plan, evolve tactics, and take action, thus becomes a critical learning practice that will manifest itself in the ability to perform in the workplace, a necessity particularly within the African construction sector, where skills are in short supply.

Many authors argue that by advocating the systematic application of theory and techniques to every situation, traditional approaches to management education fail to consider that practitioners deal with ill-

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defined, unique, emotive, and complex issues (Cunliffe, 1999). This is the very essence of the challenges that students face in their honours year when competing deadlines will test their ability to manage their time and themselves to achieve an effective outcome across all subjects. However, this only introduces the theoretical challenges of the discipline and not the practices as experienced in the field. As Hmelo-Silver et al. (2007) state: "learning the concepts and theories of a discipline is best situated in the context of the practices of that discipline".

This exposes traditional pedagogy and teaching to critical questioning, with the focus on intellectual critiques not helping students to cope with everyday realities, responding, and learning that are the essence of practice (Cunliffe, 1999). Experience and anecdotal evidence indicate that honours students experience challenges in terms of completing the academic year and that this manifests itself in mediocre performance when entering the workplace. "Students learn content, strategies, and self-directed learning skills through collaboratively solving problems" (Hmelo-Silver et al., 2007), so creating a learning environment in which students explore practices that increase interface time with one another, and explore other boundaries outside the current teaching and learning environment thus providing opportunities to tackle these deficiencies. This is in addition to students attempting to gain experience through vacation work which is undermined by a lack of practical skills.

Mo et al. (2007) emphasise that skills include an ability to think across disciplines, team working, and social and environmental awareness. Learning this in the traditional class room environment is challenging, not least due to students being unable to articulate their thoughts, nor communicate with their lecturers or one another, and an overreliance on smart phones as the only source of information coupled with an inability to read and discuss the findings of their investigations with their peers. To be effective in the workplace, and in their personal lives, students must be able to solve problems to make effective decisions; therefore, they must be able to think critically (Snyder & Snyder, 2008). The Critical Thinking Community defined critical thinking as "the intellectually disciplined process of actively and skillfully conceptualising, applying, analysing, synthesising, and / or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication, as a guide to belief and action." (Scriven & Paul, 2007)

Jackson (2015) states that "it is important to be refining, developing and practicing your skills, not simply starting to learn them", which further emphasises the need to get students out of the classroom and into a pseudo work environment. There is an idea that all millennial students need active learning (Farrow, 2016) as they have become less exposed to workplace environments and participation in physical labour activities. Furthermore, the dramatic changes in social, economic, and environmental issues experienced since the turn of the millennium has

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forced construction management programmess to produce more prepared personnel (Lee *et al.*, 2011). Simply put, students who can think critically are able to solve problems effectively. Merely having knowledge or information is not enough (Snyder & Snyder, 2008).

When addressing inadequacies of both students and programmes, it is important to understand what it is they are expected to deliver when they enter the workplace. The nine recognised functions in an organisation, and five functions of management work, provide further insight relative to the knowledge and skills required by construction managers (Smallwood, 2006). By enhancing these through the types of activities included in a team-building event, construction management programmes are improving graduates' suitability for appropriate employment. In addition, as ESECT (Enhancing Student Employability Co-ordination Team) argued, to enhance employability, it is necessary to ensure that practices that foster understanding, skills, efficacy beliefs and metacognition (appropriate personal manner) are employed in higher education programmes (Yorke & Knight, 2007).

Competency embodies the capacity to transfer skills and abilities from one area to another, and competencies are the characteristics of managers that lead to the demonstration of skills and abilities (Smallwood & Emuze, 2011). An inability to sufficiently master these competencies whilst within the higher education domain through vacation work or practical skills learning, leaves the student ill prepared when they do finally graduate, as competent practitioners often rely on a tacit knowing-in-action to help them act within circumstances (Polanyi, 1966 quoted by Cunliffe, 1999).

In terms of the contribution of core competencies to project success, it can be concluded that motives are a major contributor at operational and top management level. Affect Control Theory (ACT) encompasses attitudes referred to as sentiments, motivations and impressions (Francis, 2011), all as determinants of attitudes, are core variables of the theory and are defined as "the persistent culturally-grounded affective meaning of an entity that serves as a reference for individual experience." (Heise, 2002) Furthermore, the ACT model proposes behaviour is influenced in a process of intuitive references made to fundamental attitudes as a basis for behaviour in social interactions (Francis, 2011).

In addressing specific core competencies, based upon their contribution to project success relative to their importance, it can be concluded that aptitude, attitude, team player, focus are critical core competencies to client success (Smallwood & Emuze, 2011). Envisaging an environment outside the classroom with a unique set of physical and mental challenges to enhance these competencies becomes a strategy whereby construction management students are introduced to a collaborative problem-solving environment. This, whilst also enhancing their ability to strategise, plan, evolve tactics, and take action within a practical environment in which

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actions result in consequences for them and team mates, a pseudo project environment.

RESEARCH

Research method and sample stratum

Given the challenges recorded in the introduction, a team building event involving the honours students was undertaken on a Saturday at a resort near to the university. The event entailed five activities, namely traversing a zip line, negotiating an obstacle course, assembling a puzzle without a reference in the form of a complete view thereof, target shooting, and ejecting a plastic ball from a holed-tube filled with water. Each of the activities was entailed one or more of the following: strategising; planning; evolving of tactics, and taking of action.

Nineteen students, which could attend the team building event, were requested to complete a self-administered questionnaire within a few days after the event. All nineteen responded. The questionnaire consisted of thirteen questions, twelve of which were closed ended, and either a five-point or six-point Likert scale type question. Only the findings relative to nine of the questions are reported on due to paper length constraints. A measure of central tendency in the form of a mean score (MS) between 1.00 and 5.00 (five-point), and 0.00 and 5.00 (six-point) was computed based upon the percentage responses to the points on the respective scales to enable interpretation of the responses and to rank variables where necessary. The responses were weighted as per the figures recorded within parentheses: did not (0); minor extent (1); near minor extent (2); some extent (3); near major extent (4), and major extent (5).

Research findings

Table 1 indicates the extent to which the team building activities impacted on participants in terms of percentage responses to a scale of 1 (minor) to 5 (major), an additional point 'did not', and MSs. Given that there are effectively six points on the scale, the MSs are between 0.00 and 5.00, the midpoint being 2.50. It is notable that all the MSs are > 2.50, which indicates that in general the team building activities impacted more of a major than a minor extent on participants. However, a review of the MSs in terms of ranges provides a more detailed perspective. 2 / 7 (28.6%) MSs > 4.17 ≤ 5.00, which indicates that the impact can be deemed to be between a near major extent to a major extent / major extent: your ability to communicate with your Honours colleagues, and removing you from your 'comfort zone'. The other 5 / 7 (71.4%) MSs are > 3.34 ≤ 4.17, which indicates the impact can be deemed to be between some extent to a near major extent / near major extent: building confidence in your own abilities; your ability to complete a task; enhancing alternative

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thought processes; your ability to be creative, and improving your time management skills.

Table 1 Extent to which the team building activities impacted on participants.

Impact	Response (%)							MS	Rank
	U	Did not	Minor ....Major						
			1	2	3	4	5		
Your ability to communicate with your Honours colleagues	0.0	5.3	0.0	0.0	0.0	21.1	73.7	4.53	1
Removing you from your ‘comfort zone’	0.0	0.0	10.5	0.0	0.0	36.8	52.6	4.21	2
Building confidence in your own abilities	0.0	0.0	5.3	0.0	21.1	26.3	47.4	4.11	3
Your ability to complete a task	0.0	0.0	10.5	0.0	10.5	26.3	52.6	4.11	4
Enhancing alternative thought processes	0.0	0.0	5.3	5.3	10.5	36.8	42.1	4.05	5
Your ability to be creative	0.0	11.1	5.6	0.0	11.1	22.2	50.0	3.78	6
Improving your time management skills	0.0	5.3	5.3	0.0	15.8	47.4	26.3	3.74	7

Table 2 indicates the extent to which the team building activities enhanced participants’ various abilities in terms of percentage responses to a scale of 1 (minor) to 5 (major), an additional point ‘did not’, and MSs. It is notable that all the MSs are > 2.50, which indicates that in general the team building activities enhanced participants’ various abilities more of a major than a minor extent. 3 / 4 (75%) MSs > 4.17 ≤ 5.00, which indicates that the enhancement can be deemed to be between a near major extent to a major extent / major extent: strategise, evolve tactics, and take action. The MS relative to plan is > 3.34 ≤ 4.17, which indicates the enhancement can be deemed to be between some extent to a near major extent / near major extent.

Table 2 Extent to which the team building activities enhanced participants’ various abilities

Ability	Response (%)							MS	Rank
	U	Did not	Minor ....Major						
			1	2	3	4	5		
Strategise	0.0	0.0	0.0	0.0	10.5	31.6	57.9	4.47	1
Evolve tactics	0.0	0.0	0.0	5.3	10.5	31.6	52.6	4.32	2
Take action	0.0	0.0	0.0	5.3	15.8	26.3	52.6	4.26	3
Plan	0.0	5.3	0.0	5.3	10.5	26.3	52.6	4.11	4

Respondents were then required to indicate the extent to which the individual team building activities enhanced participants’ ability to strategise, evolve tactics, take action, and plan relative to each activity.

Table 3 indicates thus relative to the ability to strategise. It is notable that 4 / 5 (80%) of the MSs are > 3.00, which indicates that in general the team building activities enhanced participants’ ability to strategise to

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a major as opposed to a minor extent. 3 / 5 (60%) MSs > 4.20 ≤ 5.00, which indicates that the enhancement can be deemed to be between a near major extent to a major extent / major extent: puzzle; filling of tube, and obstacle course. The MS relative to shooting is > 3.40 ≤ 4.20, which indicates the enhancement can be deemed to be between some extent to a near major extent / near major extent. The MS relative to zip line is > 2.60 ≤ 3.40, which indicates the enhancement can be deemed to be between a near minor extent to some extent / some extent.

Table 3 Extent to which the team building activities enhanced participants' ability to strategise

Activity	Response (%)						MS	Rank
	U	Minor ....Major						
		1	2	3	4	5		
Puzzle	0.0	0.0	0.0	5.3	21.1	73.7	4.68	1
Filling of tube	0.0	0.0	0.0	10.5	21.1	68.4	4.58	2
Obstacle course	0.0	0.0	0.0	0.0	47.4	52.6	4.53	3
Shooting	0.0	5.3	26.3	5.3	26.3	36.8	3.63	4
Zip line	5.6	22.2	16.7	16.7	11.1	27.8	2.89	5

Table 4 indicates the extent to which the team building activities enhanced participants' ability to plan. It is notable that 3 / 5 (60%) of the MSs are > 3.00, which indicates that in general the team building activities enhanced participants' ability to plan to a major as opposed to a minor extent. 2 / 5 (40%) MSs > 4.20 ≤ 5.00, which indicates that the enhancement can be deemed to be between a near major extent to a major extent / major extent: puzzle, and obstacle course. The MS relative to filling of tube is > 3.40 ≤ 4.20, which indicates the enhancement can be deemed to be between some extent to a near major extent / near major extent. The MS relative to shooting is > 2.60 ≤ 3.40, which indicates the enhancement can be deemed to be between a near minor extent to some extent / some extent. Then, the MS relative to zip line is > 1.80 ≤ 2.60, which indicates the enhancement can be deemed to be between a minor extent to a near minor extent / near minor extent.

Table 4 Extent to which the team building activities enhanced participants' ability to plan

Activity	Response (%)						MS	Rank
	U	Minor ....Major						
		1	2	3	4	5		
Puzzle	0.0	0.0	5.3	5.3	36.8	52.6	4.37	1
Obstacle course	0.0	0.0	5.3	5.3	47.4	42.1	4.26	2
Filling of tube	5.3	0.0	5.3	5.3	36.8	47.4	4.11	3
Shooting	5.3	10.5	26.3	26.3	10.5	21.1	2.89	4
Zip line	5.3	31.6	15.8	26.3	10.5	10.5	2.37	5

Table 5 indicates the extent to which the team building activities enhanced participants' ability to evolve tactics. It is notable that 3 / 5 (60%) of the MSs are > 3.00, which indicates that in general the team

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building activities enhanced participants' ability to evolve tactics to a major as opposed to a minor extent. 3 / 5 (60%) MSs > 4.20 ≤ 5.00, which indicates that the enhancement can be deemed to be between a near major extent to a major extent / major extent: puzzle; filling of tube, and obstacle course. The MS relative to shooting is > 2.60 ≤ 3.40, which indicates the enhancement can be deemed to be between a near minor extent to some extent / some extent. Then, the MS relative to zip line is > 1.80 ≤ 2.60, which indicates the enhancement can be deemed to be between a minor extent to a near minor extent / near minor extent.

Table 5 Extent to which the team building activities enhanced participants' ability to evolve tactics

Activity	Response (%)						MS	Rank
	U	Minor ....Major						
		1	2	3	4	5		
Puzzle	0.0	0.0	0.0	5.3	42.1	52.6	4.47	1
Filling of tube	0.0	5.3	0.0	5.3	42.1	47.4	4.26	2
Obstacle course	0.0	0.0	0.0	15.8	47.4	36.8	4.21	3
Shooting	5.3	5.3	31.6	15.8	26.3	15.8	3.00	4
Zip line	5.6	33.3	22.2	11.1	16.7	11.1	2.33	5

Table 6 indicates the extent to which the team building activities enhanced participants' ability to take action. It is notable that all the MSs are > 3.00, which indicates that in general the team building activities enhanced participants' ability to take action to a major as opposed to a minor extent. 2 / 5 (40%) MSs > 4.20 ≤ 5.00, which indicates that the enhancement can be deemed to be between a near major extent to a major extent / major extent: filling of tube, and obstacle course. The MSs relative to puzzle, zip line, and shooting are > 3.40 ≤ 4.20, which indicates the enhancement can be deemed to be between some extent to a near major extent / near major extent.

Table 6 Extent to which the team building activities enhanced participants' ability to take action

Activity	Response (%)						MS	Rank
	U	Minor ....Major						
		1	2	3	4	5		
Filling of tube	0.0	0.0	5.3	5.3	36.8	52.6	4.37	1
Obstacle course	0.0	0.0	5.3	5.3	47.4	42.1	4.26	2
Puzzle	5.3	0.0	0.0	15.8	36.8	42.1	4.05	3
Zip line	0.0	10.5	10.5	21.1	31.6	26.3	3.53	4
Shooting	5.3	5.3	15.8	15.8	21.1	36.8	3.53	5

Table 7 provides a summary of the extent to which all the activities enhanced the four abilities of participants based upon the extent to which the individual team building activities enhanced participants' ability to strategise, evolve tactics, take action, and plan, in terms of MSs and ranks. In terms of the enhancement of all four abilities, puzzle (MS =

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4.39) was ranked first, followed closely by filling of tube (MS = 4.33), and obstacle course (MS = 4.32). The aforementioned were the team building activities, and required a strategy, plan, the evolution of tactics, and team action. Their mean MSs > 4.20 ≤ 5.00, which indicates that the enhancement can be deemed to be between a near major extent to a major extent / major extent. They were followed by shooting (MS = 3.26), and zip line (MS = 2.78). Then, in terms of the mean MS / ability, strategise (MS = 4.06) is ranked first, followed by take action (MS = 3.95), evolve tactics (MS = 3.65), and plan (MS = 3.60). It is notable that these mean MSs are all lower than the MSs relative to the extent to which the team building activities enhanced participants' various abilities (Table 2). Then, in the case of the latter, strategise (MS = 4.47) was ranked first, followed by evolve tactics (MS = 4.32), take action (4.26), and plan (4.11).

Table 7 Summary of the extent to which all the activities enhanced the four abilities of participants

Activity	Ability									
	Strategise		Plan		Evolve tactics		Take action		Mean	
	MS	Rank	MS	Rank	MS	Rank	MS	Rank	MS	Rank
Zip line	2.89	5	2.37	5	2.33	5	3.53	4	2.78	5
Obstacle course	4.53	3	4.26	2	4.21	3	4.26	2	4.32	3
Puzzle	4.68	1	4.37	1	4.47	1	4.05	3	4.39	1
Shooting	3.63	4	2.89	4	3.00	4	3.53	5	3.26	4
Filling of tube	4.58	2	4.11	3	4.26	2	4.37	1	4.33	2
Mean / Ability	4.06	1	3.60	4	3.65	3	3.95	2	3.82	

Respondents were required to indicate the extent to which they enjoyed and benefited from the team building activities. Both MSs > 4.17 ≤ 5.00 – enjoy (MS = 4.79), and benefit from (MS = 4.63), which indicates that the enjoyment and benefit can be deemed to be between a near major extent to a major extent / major extent.

Table 8 indicates the extent to which participants benefited from the team building activities. It is notable all the MSs are > 3.00, which indicates that in general the participants benefited from the team building activities to a major as opposed to a minor extent. 3 / 5 (60%) MSs > 4.20 ≤ 5.00, which indicates that the benefit can be deemed to be between a near major extent to a major extent / major extent: puzzle; filling of tube, and obstacle course. The MSs relative to zip line and shooting are > 3.40 ≤ 4.20, which indicates the benefit can be deemed to be between some extent to a near major extent / near major extent.

10.5% of respondents did not make a comment and 89.5% made one comment, which equates to a mean of 0.89 comments per respondent. Selected comments include: "Awesome team building exercise, thoroughly enjoyed every activity which also allowed me to interact with my classmates"; "The event really enhanced my ability to communicate

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with my honours colleagues on a different level"; "Very beneficial as it brought honours class together, so we could tackle the year ahead as a team"; "Was an eye-opener emphasising on the importance of team building, achieving and setting goals as a team.", and "Not only honours student, but also lower grades should be introduced to the team building culture".

Table 8 Extent to which participants benefited from the team building activities

Activity	Response (%)						MS	Rank
	U	Minor ……………………………Major						
		1	2	3	4	5		
Puzzle	0.0	0.0	0.0	15.8	21.1	63.2	4.47	1
Filling of tube	0.0	0.0	10.5	5.3	26.3	57.9	4.32	2
Obstacle course	0.0	5.3	0.0	15.8	26.3	52.6	4.21	3
Zip line	0.0	5.3	5.3	31.6	15.8	42.1	3.84	4
Shooting	0.0	15.8	10.5	5.3	21.1	47.4	3.74	5

CONCLUSIONS

Non-traditional academic programme interventions such as the team building event reported on, do impact on honours' students' ability, to manage themselves, strategise, plan, evolve tactics, and take action, which in turn should contribute to their ability to study, undertake assignments, projects, and especially the treatise research project, and successfully complete the honours year of study.

Furthermore, the impact should contribute to their ability to respond during employment interviews, effectively integrate into the construction industry upon employment, and to fulfil a form of management function in the industry. However, this can only be quantified post-graduation.

RECOMMENDATIONS

Recommendations include that the team building event be undertaken on an annual basis, but at first year level, that the impact thereof on participants be determined, and that further potential events directed at enhancing interpersonal skills, team building abilities, and the ability to strategise, plan, evolve tactics, and take action, be investigated.

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DECISION MAKING OF CARBON REDUCTION STRATEGIES ADOPTION – A CASE STUDY IN GREATER MELBOURNE REGION

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ABSTRACT

Contractors convert design into reality. They are presumed as a major contributor of carbon emissions from the construction development. Carbon reduction strategies were proposed in previous studies. Nevertheless, contractors were often criticised for standing aloof to adopt them. Some argued that the contractors may not have contractual leverage to challenge the decisions made by the developers and the consultants. Nonetheless, there has been a lack of research that focuses on how different construction project organisations (CPOs) may be affecting carbon reduction strategies adoption. This paper presents a study that investigates the effect of the construction project organisations have on the contactors' adoption of carbon reduction strategies. An industry survey was conducted in Melbourne, Australia. 200 questionnaires were sent to the registered contractors. Monte Carlo simulations were conducted to examine how the priorities of strategies adoption may be affected by the CPOs. The results indicate that developers and the design consultants are influential to contractors' decision in adopting those carbon reduction strategies that may incur additional project cost. The results indicate that decisions towards the adoption of strategies may not be swayed towards their effectiveness of achieving carbon reduction. Instead, tightening planning and building regulations might affect decisions.

Keywords: carbon reduction, construction project organisations

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INTRODUCTION

In Australia, construction related activities accounts for over 40 million metric tonnes, shares around one-fifth of the country's carbon emissions annually. Being the frontline of the construction operations, contractors have a significant role to play in carbon reduction. In recent years industry reports and research studies in relation to devising carbon reduction strategies have been published (ENCORD 2010; GRI 2011). However contractors are generally slow to adopt them in practice (Wong et al. 2015). In the public eye, contractors are responsible for all energy consumption in the construction process. Nevertheless, collectively bound by the project-based collaboration mechanism, contractors may be unable to change their ways of operations in isolation. However, scholars typically agreed that construction contractors are indeed capable of reducing carbon emissions in their operations (Lam et al. 2010, Wong and Zapantis 2013). The key is whether the contractors have sensible reasons not to stay passive in adopting carbon reduction strategies (Zuo et al. 2012, Ding 2008). Based on a literature review, Acquaye & Duffy (2010) pinpointed that it is difficult for contractors to change operational practice if the responding actions are in conflict with their core values. Wong et al. (2014) conducted a questionnaire survey in Australia to identify the obstacles that hinder contractors to change their carbon intensive operational practice. The findings indicated that the associated cost of introducing carbon reduction strategies may not be easily passed on to the developers due to competitive tendering. In similar context, they interviewed industry experts and found out that contractors rarely venture outside the given scope to reduce carbon emissions due to their contractually bound obligations for delivery of the projects (Wong et al. 2015). Moreover, the success of carbon reduction strategies adoption is also reliant on the cooperation from the sub-contractors and suppliers (Alhorr et a. 2014; Zuo et al. 2012). The above-mentioned studies indicate that contractors' decision to adopt carbon reduction strategies might be affected by the other construction project organisations (CPOs). Nonetheless, how different CPOs may be affecting carbon reduction strategies adoption was not investigated in a holistic manner. This paper presents a study that aims to investigate the influential powers of different CPOs on the contractor's decision of carbon reduction strategies adoption. CPOs in this paper refer to the organisations collaborating in a construction project. This includes the developers and their consultants, the main contractors and the sub-contractors.

This paper commences with a review of the carbon reduction strategies that are applicable to construction contractors. This is followed by a description of the research methodologies, with the research findings then discussed. Finally, concluding remarks and recommendations are made.

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IDENTIFICATION OF THE CARBON REDUCTION STRATEGIES

In recent years industry reports and research studies in relation to introducing carbon reduction strategies to the construction developments have been published (ENCORD 2010; GRI 2011). Strategies related to advancing technologies to optimize energy efficiency and saving, adopting less carbon-intensive materials in buildings and advancing technologies to optimize energy efficiency and saving and developing mechanisms for evaluating the environmental impact driven by construction activities were proposed (Fieldson 2009; Li and Colombier 2009; Tsai et al. 2012). While researchers advocated that the proposed strategies are conducive to carbon reduction, there is no objective measure to access if the applied strategies have achieved the anticipated outcomes. In this regard, the United Nations Environment Programme (UNEP) suggested seven strategies to help the building sector reduce carbon in construction projects, these include: demonstrating technology on buildings and rented office, moving to holistic and systematic solutions to sustainable buildings, educating the supply chain, renovating buildings to maximize the reduction of emissions, working to introduce a carbon trade mechanism for buildings, working with governments to develop policies that make a difference in emissions behaviour and dedicating research and development to zero net buildings (UNEPSBCI 2009). Nevertheless, the proposed guidelines are not project-specific, implying that they may not be effective in evaluating contractors' performance in carbon reduction. Global Reporting Initiatives (GRI) (2011) specifically developed guidelines for construction contractors to report their sustainability performances whereby their performance is assessed under three key aspects: management approach, strategy and profile and performance indicators. Similar, the developed guidelines have not proposed any project-specific measure to evaluate these strategies.

In this respect, the European Network of Construction Companies for Research and Development (ENCORD) developed an inventory that evaluates the carbon emitted by contractors in a construction project specifically. The inventory proposes evaluating carbon emission under twelve aspects as shown in Table 1. This study adopts the work of ENCORD (2010) as the proposed inventory is considered more suitable to evaluate contractors' carbon reduction practice.

RESEARCH METHODOLOGIES

The questionnaire design

To accomplish the research objectives, a questionnaire survey was conducted for data collection. The survey questionnaire contains three parts. Part 1 deals with demographic information about the respondents. Respondents were asked to specify a project they had been involved in for at least one year, and the questionnaires of those not having taken part in a specified project for more than one year were discarded. Part 2 seeks to solicit the degree of respondents' agreement (from 1 to 5 representing 'strongly disagree' to 'strongly agree' respectively) on whether the strategies were in place to reduce carbon emissions in their projects (refer to the operative statements of Table 1). In Part 3,

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respondents were asked to express their degree of agreement (from 1 to 5 representing 'strongly disagree' to 'strongly agree' respectively) on the impact of construction project organisations on the contractor's decision to adopt carbon reduction strategies. The impacts of 5 types of construction project organisations: developers [CPO_1], design consultants (architects/ engineers) [CPO_2], project management consultants (superintendent/ other equivalent project managers) [CPO_3], main contractors [CPO_4], and sub-contractors [CPO_5] on decision making were studied. This study received approval from the local university research ethics committee whose clearance standards are outlined in the Australia National Ethics Application Form (NEAF).

Carbon Reduction Strategies	**Respective Operational Statements**
Reducing fuel (project) [CRS1]	Reduce fuel for plants and machinery in use on site
Reducing fuel (premises) [CRS2]	Reduce fuel for use in premises which support the company's activities (i.e. offices and godowns)
Reducing process emissions [CRS3]	Reduce carbon emissions from physical and chemical processing involved in the production of mineral products (such and cements) and metal products (such as steel)
Reducing electricity (project) [CRS4]	Reduce electricity for plants and machinery in use on site
Reducing electricity (premises) [CRS5]	Reduce electricity for use in premises which support the company's activities (i.e. offices and godowns)
Reducing imported heat [CRS6]	Reduce heat purchased by the company for use at the company's project and premises
Reducing vehicle fuel [CRS7]	Reduce the use of vehicles travelling on public highways
Reducing the use of public transport [CRS8]	Reduce the use of public transports by the employees
Monitoring sub-contractors [CRS9]	Coordinate with sub-contractors at project level to achieve items 1 to 8
Reducing wastes [CRS10]	Reduce construction wastes and the associated transportation for disposal
Reducing high embodied CO2 materials [CRS11]	Reduce the use of materials with high embodies CO2 like structural steel concrete, reinforcement, cladding, aggregates and bituminous products
Reducing emissions from the facility [CRS12]	Reduce carbon emissions resulting from the built object through better design

Table 1: Carbon reduction strategies proposed by the ENCORD (modified from (ENCORD 2010)

Data collection and analysis

The targeted respondents for this study were identified from the registered contractors list maintained by the Masters Builders Association of Victoria. Master Builders is a major building and construction industry association in Australia, and its members represent 95% of all sectors of the Australian building industry. 200 respondents were randomly selected

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from the registered contractors list. They were invited to participate in the survey via either an online platform supported by Qualtrics or hardcopies delivered by our research team. To avoid disruption to selected hardcopies recipients, the research team initially sought permission via telephone before visiting the respective companies in person. Concerning data analysis, firstly the mean scores of the respondents' degree of agreement on the adoption of carbon reduction strategies and the impact of construction project organisations on the contractor's decision were compared. Furthermore, Monte Carlo simulations were conducted to examine how the priorities of strategies adoption may be affected by the construction project organisations. Monte Carlo simulation is a computerized mathematical technique that uses the Multiple Regression data set to provide an array of possible outcomes and probabilities based on sensitivity analysis. This simulation allows easy identifiable visuals on what inputs have the biggest effects on the dependent variable. The same approach had been successfully adopted by Hong et al. (2016) who adopted Monte Carlo simulation to identifying parameters for measuring greenhouse gas emissions in construction projects. In this study, five multiple regression analyses were conducted to investigate how the impact of the CPOs (as an dependent variable) may affect contractors decision of carbon reduction strategies adoption (as an independent variables). The broad equation of multiple regressions is shown as below:

$CRS_x = a + b_1CPO_1 + b_2CPO_2 + b_3CPO_3 + b_4CPO_4 + b_5CPO_5 + \varepsilon$

Where:

CRS_x = *Dependent variable (i.e. the adoption of one out of twelve carbon reduction strategies* CRS_1 to CRS_{13}*)*

CPO = *Independent variables (i.e. impact of a particular construction project organisations on carbon reduction strategies adoption)*

a, b1, b2……b5 = *Unknown constant*

ε = *Random error for any given set of values for* CPO_1 *to* CPO_5

The Multiple Regression results were then further analysed through Monte Carlo simulation to examine the influential powers of the construction project organisations on the decision of carbon reduction strategy adoption.

RESPONSE RATE AND SAMPLE PROFILE

A total of 200 questionnaires were dispatched. 46 respondents returned the questionnaires with 2 replies excluded due to being incomplete. 44 valid responses were used representing a 22% response rate. The study has attracted a reasonable response rate in comparison to other questionnaire surveys in the construction field normally ranging from 25% to 30% (Wong et al. 2012). Likewise, the response rate of the current research is similar to that of the study related to carbon emissions

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conducted by Lam et al. (2010) that received 100 responses while 652 questionnaires being sent out (equivalent to 15% response rate). Among the respondents' backgrounds, 29 out of 46 (i.e over 70% of the) respondents have had more than 10 years' project management experience. The creditability of the respondents is indicative of their service to the industry thus their responses are considered to be reflective to the industry's views in the greater Melbourne region.

FINDINGS AND DISCUSSIONS

Adoption of carbon reductions strategies

Participants were asked whether they agreed with CRS1 to CRS12 were adopted to reduce carbon emissions in their projects on a 5 point likert scale from 1 "Strongly Disagree" to 5 "Strongly Agree". The mean scores **and standard deviations (S.D.) are presented in Table 2.**

Carbon Reduction Strategies	**Mean**	**S.D.**
Reducing fuel (project) [CRS1]	2.80	0.85
Reducing fuel (premises) [CRS2]	2.66	0.89
Reducing process emissions [CRS3]	2.48	0.98
Reducing electricity (project) [CRS4]	3.06	0.90
Reducing electricity (premises) [CRS5]	3.43	0.98
Reducing imported heat [CRS6]	2.84	0.99
Reducing vehicle fuel [CRS7]	2.95	0.94
Reducing the use of public transport [CRS8]	2.95	1.10
Monitoring sub-contractors [CRS9]	2.45	0.98
Reducing wastes [CRS10]	3.08	0.97
Reducing high embodied CO2 materials [CRS11]	2.30	1.02
Reducing emissions from the facility [CRS12]	2.37	1.02

Table 2: Respondents' opinions of carbon reduction strategies adoption in projects

The respondents showed neutral or slight agreement towards the adoption of 8 out of 12 strategies throughout their projects. These statements generally received scores around the mid-point of the five-point scale. Mean scores of CRS 4 "Reducing electricity (project)", CRS 5 "Reducing electricity (premises)" and CRS10 "Reducing wastes [CRS10]" are greater than three in the five-point scale, indicating respondents tend to agree that these strategies were adopted onsite. Interestingly, CRS4, CRS 5, CRS 10 are strategies that are contributive to cost savings. Moreover, adoption of these strategies may not necessarily rely on the collaboration of the other construction project organisations. Conversely, strategies that implies higher operational cost or require collaborative efforts among construction project organisations might not be as popular. For examples, means score of CRS 11 "Reducing high embodied CO2 materials" and CRS 12 "Reducing emissions from the facility" are among the lowest of the 12 strategies. Successful adoption of these strategies requires preplanning of the project design and alternative construction methodologies. Decisions on designs are heavily reflected on the construction operations. Carbon reduction strategies may affect the conventional approach of estimating profit margin in projects might not be easily accepted by the contractors. Despite developers, consultants as well as the subcontractors might be willing to help, the industry practice to award construction project to the lowest bidder may not encourage new ways of construction operations that enable carbon reduction.

Impact of project organisations on strategies adoption

Multiple linear regression analyses were used to examine the impact of construction project organisations on the contractors' adoption of carbon reduction strategies. The results were further analysed through Monte Carlo Simulation in order to articulate the impact (in terms of the Contributions to Variance (CV) and normalised contributions to variance (NV)) of each of the CPOs on the adoption of a particular CRS.

The outputs of the Monte Carlo simulations indicated that the design consultants have the greatest impact on the contractors' decision made on CRS3 Reducing process emissions (CV= 55.06; NV= 0.52), CRS11 Reducing high embodied CO2 materials (CV= 65.58; NV= 0.42) and CRS12 Reducing emissions from the facility (CV= 80.39; NV= 0.42). The results reveals that some carbon reduction strategies may not likely be adopted without the support of the design consultants. In particular, the respective strategies are all related to building design. Some scholars describe construction contractor as merely an executor of the designers' instructions that may have long term consequences in carbon emissions (Acquaye & Duffy 2010, Wong et al. 2015). Without endorsement, contractors may not initialise any change to foster carbon reduction

The means scores indicated that contractors generally disagree that CRS 11 "Reducing high embodied CO2 materials" and CRS 12 "Reducing emissions from the facility" were adopted. In this aspect, the Monte Carlo simulations results further suggest that the developers and design consultants are most influential to the adoption of these strategies. The results indicate that developers and the design consultants are influential to contactors' decision in adopting those carbon reduction strategies that may incur additional project cost. The results looks contradictory to previous studies that reported the industry's enthusiasm towards adoption of greener and more energy efficient designs in construction projects (Zuo et al. 2012). However, this may be linked to the fact that the related carbon reduction strategies have to be adopted at some point in order to comply with the stringent planning and construction regulations. In Australia, Green Stars and National Australian Built Environmental Ratings Scheme (NABERS) were introduced which serves to establish a common-ground for rating building energy efficiency (Iyer-Raniga and Wong 2012). Some State Governments in Australia such as Victoria have

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tightened their regulations to disapprove new construction or alteration works that don't reach a certain level of Green Star or NABERS standards (Iyer-Raniga and Wong 2012). The introduction of these regulations has been viewed as the motives toward forcing behavioural changes into the construction sector (Iyer-Raniga and Wong 2012).

Strategies	Developers		Design Consultants		Project Management Consultants		Main Contractor		Sub-contractor	
	CV	NV	CV	NV	CV	NV	CV	NV	CV	NV
CRS1	45.50	0.32	33.60	0.24	25.60	0.18	25.70	0.18	11.00	0.08
CRS2	9.40	0.05	22.23	0.12	16.49	0.09	90.15	0.48	47.62	0.26
CRS3	30.72	0.29	55.06	0.52	7.50	0.07	4.90	0.05	7.50	0.07
CRS4	6.79	0.06	19.77	0.16	3.82	0.03	79.63	0.66	11.24	0.09
CRS5	16.70	0.13	4.14	0.03	83.80	0.64	14.05	0.11	11.83	0.09
CRS6	3.82	0.01	70.67	0.23	64.01	0.21	96.92	0.32	65.42	0.22
CRS7	11.70	0.07	17.03	0.11	48.57	0.31	65.98	0.42	14.41	0.09
CRS8	2.53	0.02	8.60	0.08	6.80	0.07	65.30	0.64	18.60	0.18
CRS9	15.48	0.11	36.71	0.25	20.62	0.14	41.26	0.28	33.00	0.22
CRS10	25.44	0.13	60.48	0.32	0.42	0.00	58.95	0.31	43.68	0.23
CRS11	34.47	0.22	65.58	0.42	21.43	0.14	25.49	0.16	8.36	0.05
CRS12	67.51	0.35	80.39	0.42	1.14	0.01	30.39	0.16	13.75	0.07

Table 3: Influential power of the construction project organisations on carbon reduction strategies adoption

Main contractors have the greatest impact on their decision made on CRS2 Reducing fuel (premises) (CV=90.50; NV= 0.48), CRS4 Reducing electricity (project) (CV= 79.63; NV= 0.66), CRS8 Reducing the use of public transport (CV= 65.30; NV= 0.64), and CRS10 Reducing wastes (CV=58.95; NV=0.31). The results can be explained by the cost to be undertaken by the main contractors. Main contractors prefer to adopt carbon reduction strategies that can foster cost savings. Main contractors are charged on a variable amount dependent on the wastes they dispose to the landfill. Unless the strategies adoption involve design change, main contractors are more likely to change operational behaviour in order to save energy consumption from the construction operations. As such, the contractors' decisions towards the adoption of strategies may not be swayed towards their effectiveness of achieving carbon reduction, but their financial interests.

THE CONCLUDING REMARKS

There is a candid need to determine why the construction contractors has been criticised as slow and not motivated to adopt carbon reduction adoption. This study aims to investigate the impact of construction project organisations on the main contractor's decision on adopting carbon reduction strategies. Data collected from a questionnaire survey suggest that contractors resist adopting carbon reduction strategies that may involve endorsement of the developers or those strategies that may erode their profits. The results of the Monte Carlo simulations indicate that design consultants and the developers may have influential power on the contractors' decision made on carbon reduction. However, the results also indicate that contractors don't always adopt strategies with the interest of carbon reduction. Instead, it is suggested that the motives of strategies adopted are driven by the financial interest of the individual construction project organisations and the tightening government regulations.

This study contributes to identifying the role played by construction project organisations on the contractors' adoption of carbon reduction strategies. However, this information should be taken into consideration with limitation. The comparison of mean scores reported in the discussion section should be read with due caveats on the limitations of the working sample and the constraint on the scope of research. It should be noted that the respondents of this survey were randomly selected from the contractors list registered in the State of Victoria, Australia. The results of this study can be viewed as a case study conducted in the greater Melbourne region. As a further study this survey can be extended to collecting data in other Australian states and territories as well as other countries.

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LESSONS FOR THE OFF-SITE MANUFACTURE OF HOUSES IN AUSTRALIA

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ABSTRACT

In Australia, the current traditional construction industry struggles to supply housing to satisfy increasing demand. Literature indicates that house construction completion times using traditional methods are increasing due to a number of factors. These include an increasing decline in the numbers of skilled workers, a lack of innovation in the industry and a disjointed framework for efficient production. It is often suggested that the increased use of off-site manufacture (OSM) to produce housing will assist in solving the demand issues Australia is facing. This paper focuses on detached housing which represents 70% of the housing production in Australia (ABS, 2009). OSM for housing is defined in this paper as all components manufactured, services installed and finishes completed in a factory ready for transport to site and assembly on-site in a short time frame. The study described here, seeks to identify factors to further inform the discussion of OSM so that it can be evaluated in the Australian context. The paper has examined five countries experiences of OSM of housing, and distilled the factors which influenced the success and failure of OSM in those countries. Successful introduction of OSM housing is arguably possible through use of the application of the criteria and variables presented in this paper.

Keywords: Housing, off-site manufacturing, traditional construction.

INTRODUCTION

Shortages of housing have been experienced worldwide at various times and for various reasons, and those shortages are currently being experienced in many countries. This paper addresses the severe lack of housing currently being experienced in Australia (Dalton, Hurley, Gharaie, Wakefield, & Horne, 2013; Donald, 2013). Prefabrication is frequently proposed to satisfy such shortages, but with mixed results. Previous research seeking criteria for OSM in Australia analysed case studies in China (London, 2014). This paper examines five countries to identify prefabrication criteria and variables to inform the Australian housing industry. The countries studied were United Kingdom (UK), United States of America (US), Japan, Germany and Sweden. These countries attempted to address housing shortages via the use of prefabrication and OSM, and have all experienced successes and failures in various degrees.

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These countries prefabricated houses in the post-World War 2 (WW2) period and currently use OSM to produce housing. This paper firstly reviews the immediate post WW2 period and then compares this to the recent actions of those countries with respect to OSM of housing.

THE POST WORLD WAR 2 MODELS: GOVERNMENTS AND BUREAUCRACY

Literature describes the poor perceptions of government instigated industrialised housing systems developed during the post Second World War (WW2) period, and the ongoing antipathy for OSM housing held by the market to this day. Gay (1987) describes the actions of the UK Government seeking to increase housing supply and address the deficit post WW2 by using OSM. The deficit was a result of both wartime destruction of property and a lack of construction activity during that war. An alternative method was required to satisfy demand mainly due to a lack of capacity in the traditional housing industry at that time; supply was increased through the use of prefabrication. Government policy called for various companies to produce houses using identical accommodation briefs, with the proviso that the life expectancy of the houses was to be 10 years, 15 at most (Gay, 1987).

Vale (1995) argues that these policies resulted in prefabricated houses that were less attractive than site built housing, thereby compromising positive perceptions about OSM housing. The procurement methods used by the UK Government further damaged the concept of prefabrication by ignoring the "economies of scale" that could be realised by mass production. Manufacturers were allowed to develop their own components and systems. As a result of individual set-up costs and designs of components, the cost of prefabricated houses exceeded that of traditional site built houses (Vale, 1995).

Davies (2005) outlines similar actions by the US Government. These encouraged housing production through prefabrication to address the housing shortages experienced post WW2. The shortages were caused by a lack of construction during the war and an absence of trade skills. The general brief of the US Government for prefabricated housing during and after WW2 was for speed of supply, demountable formats and reduction of on-site labour (Kelly, 1951). Kelly (1951) describes setbacks for acceptability of these houses by the market and institutions. The factory product was regarded as inferior to site-built. Davies (2005) concluded prefabricated dwellings were regarded as being suitable only to people of lower incomes and social status.

In Japan, following WW2 reparations and adjustments to occupation, the Japanese industry commenced production of prefabricated houses between 1950 and 1960. Noguchi (2003) describes the first houses mass-produced in factories as being identical in form and monotonous in

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character, and regarded by the market as being of low quality and of poor appearance. The market rejected these early models but the next iterations of OSM have been extremely well received.

Germany post WW2 experienced the same circumstances as Japan including reparations, rebuilding and production of houses to supplement traditional methods to satisfy housing shortages. Similarly early examples were rejected as being of poor quality by the market (Venables, Courtney, & Stockerl, 2004).

For Sweden post WW2, the model varies, in part due to their exclusion from WW2. Nonetheless, Sweden experienced housing shortages in that period. The Government's "Million Homes Program" was initiated to upgrade poor quality housing to suit a rising need for urban housing that met modern housing standards (Hall & Viden, 2005). Due to shortages of construction skills, industrialised production systems were used for the large scale developments of apartments and some detached housing. Hall and Viden (2005) concluded that the program, although successful in increasing the quantity of housing, resulted in uniform and monotonous buildings. They also criticised the lack of community consultation that occurred during the process.

CURRENT ASPECTS OF OSM, ATTRIBUTES FOR SUCCESS AND FAILURE

UK and US

The legacies from post WW2 OSM activity continue to retard the development of OSM through market resistance. This is particularly so for the UK. In contrast the US market enjoys greater acceptability attributed to the widespread use of manufactured/mobile homes. In the UK, Craig, Laing, and Edge (2000) in their study sought to identify ways to mitigate social and cultural resistance to OSM housing. Craig et al. (2000) argue that security of investment is problematic for housing produced by non-traditional methods. They also found OSM housing which emulates conventional housing forms are more likely to be accepted by the market, thereby constraining innovation. Further, Edge et al. (2002) refer to the construction industry overall, including professionals, as being reluctant to innovate due to financial risk related to poor market acceptance. Finally, they refer to resistance by institutional bodies and financial houses to accept OSM houses as financially secure models. OSM of housing in the UK and US (precluding mobile homes) is estimated to be in the order of 3% of housing production.

Germany

OSM housing in Germany also experienced the adverse perceptions of post WW2 prefabrication. However, the German OSM industry addressed these perceptions by creating a prefabrication industry association and

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establishing rigorous quality standards to assure the market of quality and durability (Venables, Courtney, et al., 2004). Also of note, is the extensive use of demonstration villages throughout Germany. These give the marketplace wide choice and the convenience of experiencing OSM products first hand (Venables, Courtney, et al., 2004). Approximately 13% of the housing market is satisfied by OSM.

Japan

For Japan, Linner and Bock (2012) argue that the Japanese culture positively accepts modular designed products. They describe Japan's construction history as dominated by post and beam systems and modular planning. Importantly, the Japanese regard the use of quality oriented methods of production in factories as a desirable attribute (Noguchi, 2003).

Literature identifies the need for flexibility and customisation of OSM housing to satisfy the housing market (Barlow & Ozaki, 2004; Schoenwitz, Gosling, Naim, & Potter, 2014). In the most successful examples in Japan (and Germany), face to face meetings are conducted with clients when preparing designs for housing. It is policy however to ensure options are limited as additional costs may result due to waste and high stock levels. Noguchi (2003) points to the use of mass customisation through mass production of components rather than whole house models, enabling the market to customise and the producer to enjoy economies of scale. Japanese OSM producers have therefore been able to offer customisation of interior and exterior design components as well as individual space arrangement. Housing manufacturers in Japan also offer attractive service warranties and follow up inspections, and satisfy around 13% of the market.

Sweden

OSM housing producers in Sweden also recognise the need for customisation (Höök, 2006). They do this to compete with the market's belief that clients have a high degree of control in the process of traditional site-built housing. Hook and Stehn (2005) observe that value creation for OSM product by the OSM industry emulates a traditional sense of trust and control, suggesting this can be achieved through strategic alliances and demonstration villages. Reinforcing this Harris and Buzzelli (2002), argue that the general public have a basic understanding of traditional house production processes and suggest the manufacturing process should be translated and applied to OSM product, a process fully understood by the German and Japanese manufacturers. The OSM of housing in Sweden produces around 80% of the market, to a large measure a reflection of dealing with difficult site conditions.

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Manufacture Rather than Construction

There is evidence that a manufacturing regime rather than construction methodology is an important factor for OSM (Engstrom, 2012; Höök, 2006; Meiling & Johnsson, 2009; Naim & Barlow, 2003). For example Swedish OSM of housing is produced by manufacturers who evolved from lumber companies seeking to maintain their market share of the housing industry (Bergdoll, 2008)). In Japan OSM of houses is performed by companies such as Toyota, Sekisui, Sekisui Heim, Daiwa and Misawa, all of whom are classified not as constructors but as manufacturers. In the US and the UK, the production of OSM houses is by manufacturers, rather than the traditional construction industry (Pan, Gibb, & Dainty, 2012).

Mass production should be based on standardised parts or platforms, rather than standardised houses (Veenstra, Halman, & Voordijk, 2006). This facilitates economies of scale based upon a limited and controlled stock holding, which is possible when flexible use of components embody "just in time" (Gann, 1996). Importantly, Nadim and Goulding (2011) discuss control of the variety and number of components as enabling commercial aspects to be satisfied for manufacturers producing houses in volatile markets.

The adoption of manufacturing industry methodologies rather than traditional construction methods is supported by German, Swedish and Japanese examples of houses fabricated in factories. Piroozfar and Farr (2013) assert there are ample examples of the successful use of manufacturing to produce buildings using new organisational structures, new processes, new technologies, ICT and flexible automation to create a more sustainable housing industry. Manley (2009) supports the concept of manufacturing rather than construction for innovation in the built environment, suggesting that manufacturers would enjoy a more consistent and managed work flow than typically discontinuous construction projects. Manufacturers should therefore be able to address and maintain effective research and development programs. The literature endorses manufacture rather than construction noting it is only mass production by manufacturing processes which can meet demand (Engstrom, 2012; Kieran & Timberlake, 2004; Meiling & Johnsson, 2009).

FUTURE FACTORS FOR OSM

Sustainability

In the 21st Century, the issue of sustainability has become increasingly relevant to human activity. Luther (2009) argues that housing currently creates an unacceptable energy footprint and must be critically reviewed to address issues of sustainability. Luther (2009) also believes OSM is capable of redressing some of the negative aspects for sustainability in housing. There are important considerations to be addressed in regard to

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Green House Gas emissions (GHG) and waste. Barrett and Wiedmann (2007) found in a comparative study of on-site versus off-site housing, that the off-site model achieved 17% lower emissions of GHG (against UK 2006 building codes), increasing to 30% lower GHG using the UK level 4 sustainability code. Significantly their research claims traditional on-site construction methods cannot reduce emissions unless there is significant change to on-site methods. One avenue could be applying principles of lean construction.

Hyder (2012) describes construction and demolition waste for Europe, UK, US, Germany and Australia as unacceptable. For example, in Europe it is estimated that 25% of all waste is generated from construction sources. Teo and Loosemore (2001) estimate the Australian construction industry contributes between 20% – 30% of annual landfill. Literature suggests construction waste could be substantially reduced using factory production systems and therefore enhance the opportunities for success for all OSM construction applications (Tam & Hao, 2014).

Time, Cost and Quality

The often stated significant advantages of off-site manufacture compared to on-site construction are time, cost and quality. These attributes should be the common benefits of OSM. For Blismas, Pasquire, and Gibb (2006) and Pan, Gibb, and Dainty (2005) however, the reality for OSM (particularly in the UK), is that few of these benefits have been realised. In the UK Vale (1995) reported that post WW2 prefabricated houses were more expensive than traditionally constructed ones. The cost of OSM in the UK according to Venables, Barlow, and Gann (2004) is greater than on-site construction. This is attributed to failure to contain costs, uncertain supply chain management and poor management of the site itself. In the US, the Lustron house program post WW2 geared up for mass production which was never realised. It was subsequently wound up with massive debts (Kelly, 1951). Also in the US, the General Panel Company demonstrated innovative cassette systems, but could not achieve market share to cover investments and failed financially. However Pan, Dainty, and Gibb (2012) claim OSM can provide a superior solution if a balanced criteria including factors other than cost are considered. For Japan, the additional cost for OSM compared to traditional methods is stated by Noguchi (2003) as 8%. It is interesting to note the Japanese market regards OSM product as superior in quality and therefore a good investment. Clearly, these are important lessons for the Australian proponents of OSM (Dalton et al., 2013).

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Promotion and Marketing

Exhibitors of OSM housing in German promotional villages include Huf Haus, Massa Haus and Weber Haus. These are well-known names in the OSM market. Japan similarly has demonstration villages for OSM housing

(Noguchi, 2003). While there are a number of producers of factory built houses active in the Australian market to my knowledge they offer demonstration houses for inspection only within their factory premises. This precludes direct comparison with site-built houses, a comparison which may neutralise the poor perceptions described earlier. In both Japan (Noguchi, 2003) and Germany (Venables, Courtney, et al., 2004), prefabricated houses are regarded as being of high quality. The introduction of strict quality standards and quality management has engendered this perception. Germany and Japan present a precedent for the establishment of exhibition villages in Australia to demonstrate OSM examples.

SUMMARY OF FACTORS

Governments have considerable influence over housing and construction clearly demonstrated by the actions after WW2. More recently efforts by governments indicate growing interest by them in promoting alternative methods of producing buildings, such as OSM. Consumer perceptions have been shown to be a serious impediment to successful sales of OSM housing. Governments should be encouraged to set policies to promote innovation for housing production; however they must be carefully managed to prevent poor outcomes. It should be noted Australian Governments have recently invested in OSM research, the results yet to be tested.

In Germany and Japan use of demonstration villages has enabled the market to compare on-site with OSM resulting in a higher market share; Australian manufacturers should follow this example. Additionally, as shown in Japan, demonstrating high quality products defuse poor perceptions of OSM, as experienced in Australia.

From the examples in the UK and US, preparing a workable business case is an imperative. Financial failure is a certain outcome if the initial investment is unable to be covered by sales. There have already been similar failures in Australia.

One of the poor perceptions held by the markets is that of a “cookie-cutter” market offering, this view has been diluted in Japan, Germany and Sweden by offering options and the opportunity to customise housing. It has been shown however that limited options will mitigate potential waste or unacceptable stock holdings adversely affecting operational costs and ultimately housing affordability. Customisation to match bespoke on-site construction methods is possible and desirable if market needs are to be met. This requires systems which produce standard components rather than standard designs, for example through the use of product platforms (similar to watch manufacture).

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Successful examples of OSM have been shown to be a manufacturing rather than a construction paradigm. Reasons for this include skills shortages (although this could also be an issue for OSM), less exposure to open site conditions, more efficient and safer assembly on site reducing time and errors and importantly injuries to personnel. In Australia mass production could prove difficult as the market is relatively small. As demonstrated, financial failure is likely when large investments cannot be supported by the market. Rather than establishing new single purpose manufacturing facilities, use of existing manufacturers would contain costs. Use of design for manufacture and assembly principles can reduce on-site time. Manufacturing regimes which incorporate suitable management systems will improve quality and at the same time enable customisation to improve choice for customers

Sustainability may represent another factor supporting a change to OSM of housing. Over 60 % of Australians now have concern for the environment and global warming according to the CSIRO (Leviston, Price, Malkin, & McCrea, 2014). Zero waste and zero emissions will not only reduce the cost of housing but also reduce the cost of operation. The argument of improving sustainability through reduction in waste (labour and materials) and emissions could be an important marketing tool as well as producing substantial cost benefits.

CONCLUSION

This paper has reviewed factors affecting OSM of houses in five countries to inform OSM in Australia. Using traditional construction methods for the supply of housing has demonstrated poor characteristics for productivity and affordability. Further, the traditional on-site construction methodologies are unlikely to improve due to skills shortages and resistance to change. This has inspired a search for alternatives. There is agreement that adopting factory production methods should assist in improving the volume of housing supply, reduction in cost and better quality.

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INSTILLING RESILIENCE IN BUILT ENVIRONMENT STUDENTS

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ABSTRACT

Upon graduation from University many students lose access to support structures such as peers, academic mentoring, etc. This may lead to tension, stress and failure to perform effectively in their new workplaces, especially if the workplace itself is stressful, as it is in construction. Evidence indicates that the construction sector is a uniquely stressful environment, where the development of resilience is imperative for success. There is currently a perception that the development of resilience skills is not included as learning outcomes within units of study within the built environment discipline. In order to determine the scope and depth of resilience within construction curricula, staff and students from seven universities were interviewed using a semi structured instrument. These interviews were preceded and followed by industry roundtable discussions to contextualize enhanced learning opportunity and benefit. Emerging themes suggest that there are many opportunities to provide resilience learning within curricula with little adaptation required. Examples of useful case study type introductions to industry that may bolster students were provided by the interviewees. These examples are utilized in a Resilience Toolkit that is outlined. Noteworthy advice from students regarding best practice lecturing suggests that an academic with a balanced career path, comprising both industry experience or industry contacts to draw from, together with academic standing appears to provide a learning experience best suited to incorporate resilience behaviours and requisite training.

Keywords: Resilience, coping, construction, curricula, built environment

INTRODUCTION

Construction and built environment companies operate in highly competitive markets with relatively low profit levels. Organisational complexity is driven by projects that are run with tight deadlines and have significant budget constraints with substantial penalties if project milestones are not met. These factors add to the stressful nature of the industry. Historically, the route to middle and higher levels of management

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has been vocational with career advancement from a trade background through the organisational structure where coping and resilience became embedded. Professional career advancement has changed this, with degree qualified graduates taking on increasingly higher levels of management and concomitant responsibility at an earlier stage in their career. Research described in this paper, adopts the premise that whilst at University students are provided with high levels of support across a range of avenues that helps them cope with their day-to–day learning activities and their experiences and interpretations of industry activity. Upon graduation, most students lose access to these support mechanisms. This increases tension and stress which can lead to failure to perform effectively in their new workplaces, especially if the workplace itself is stressful, as it is in construction. A paucity of research on resilience in construction education was identified at the commencement of the project reported upon. However, more recently we are drawn to the work of the following (Holdsworth, Turner, & Scott-Young, 2017; Michelle Turner, Holdsworth, & Scott-Young, 2016; M Turner, Scott-Young, & Holdsworth, 2015; M Turner, Scott-Young, & Holdsworth, 2016).

RESILIENCE

Resilience has been researched since the 1970s, largely within psychology, (Tusaie & Dyer, 2004, p. 3). Early resilience research examined children who appeared to be invulnerable to adverse life situations (Earvolino-Ramirez, 2007). Over time, the original term "invulnerable" was replaced by the term "resilience". As resilience research has developed it has focussed on the mechanisms by which it operates. Resilience promoting factors have commonly been discussed within three broad areas: individual young people, their families and the societies in which they live (Garmezy, 1991). A framework of resilience includes protective processes; for example, resources, competencies, talents, and skills that sit within individual-level factors; social-level factors, for example within the family and peer network, and societal-level factors, for example the whole school environment and the community.

This research defines resilience as behavioral, attributional or emotional responses to the shocks and challenges graduates would inevitably face upon entering the construction industry.

Various researchers have designed different models of resilience (Caldeira & Timmins, 2016; Gillespie, Chaboyer, & Wallis, 2007; McAllister & McKinnon, 2009; Tusaie & Dyer, 2004; Tusaie, Puskar, & Sereika, 2007; Windle, 2011). The main factors of resilience models or frameworks have been described as personal, family and social perspectives of the individual. In addition, mental and physical aspects were also included and emphasized in various models. Incorporating antecedents, protective and risk factors and consequences as components of these models, researchers attempted to explain the link between different factors. Resilience is shown to be evident in times of transition, where there is a great deal of stress

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(Beasley, Thompson, & Davidson, 2003). Walker, Gleaves, and Grey (2006) argue the importance of resilience in higher educational contexts when considering the enduring demands placed upon students entering university, namely, increases in cognitive complexity, comprehension of uncomfortable and unfamiliar ideas, and the questioning of accepted attitudes and behaviours.

Analysis of the literature aligned with a desk audit together with preliminary discussion between the project stakeholders/ team suggested several key factors of resilience that affect construction management students most significantly. The team brought together their knowledge of CM curricula, detailed analysis of extant models of resilience (described above), a comprehensive literature review from a broad range of disciplines to develop a framework of resilience. The framework established the relationship between different components of resilience. The following explains the influence of one factor upon another in the framework and examples are provided in Table 2 at the end of the paper.

Antecendents

Adversity and change are considered antecedents along with several resources individuals have in their personal, family and social life. In the case of negative antecedents, for example adversity and change, deemed risk factors, are strengthened with the influence of personal (low self-esteem) and environmental (family disharmony or lack of support) factors. Alternatively, the presence of protective factors, for example, personal (motivation), family (parents' support), university (mentor guidance) and work (supervisor's appreciation and work-life balance) can develop individual resilience and minimize the impact of negative outcomes (stress and anxiety) created by strong input of risk factors.

Resilience

The tension between the positive outcomes from protective factors and negative outcomes from risk factors can be moderated by level of resilience which work as a 'striking balance'. With strong presence and active role of protective factors, resilience of individuals can be increased and remain stable and provide a good balance which can result in better consequences, for example understanding a problem, personal control and growth and an ability to maintain a constant level of competence and performance. On the other hand, the absence of protective factors and their influence can deliver an imbalance between the positive outcomes and negative outcomes and a physical and mental breakdown may occur as a negative consequence due to a poor level of resilience.

Interventions

When contextualizing the resilience themes in the construction management field, it is proposed to introduce several interventions, for example, role play, teamwork, workshop inductions on resilience, strong mentorship, reflection on individuals personal, family and academic as well

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as future work life. Along with the strong influence of protective factors, these interventions can add significant benefit and work as a safeguard and lead an individual to favorable consequences and outcomes.

This proposed framework was applied to existing built environment degree programmes and an action research study developed to trial the framework and consequesntly develop a toolkit for resilence.

METHODOLOGY

This research project was largely exploratory following Brown (2006), a new problem was tackled with an objective to build a better understanding of building resilience in a tertiary environment from a student's perspective (Singh, 2007). A preliminary methodology was determined by the nature of the research and the investigative design (Schuilin & Kiewiet, 2016). Various methodologies were assessed, consequently 'action research' was determined as the most appropriate overriding methodology due to its flexible enquiry process allowing for incrimental understanding, evaluation and improved practice outcomes (Bassey, 1998; Dick, 2002; Frost, 2002) (Hien, 2016; McNiff, 2013; Rossman, 1998).
The project concerned the resilience training of undergraduate students in Australian construction management degrees. There are a limited population of universities that provide construction management degrees in Australia, the majority of these form part of the AUBEA network. Through this network a sample of degree programs was obtained wherein a purposive sample of potential participants was derived. The purpose criteria being that academics and students were from an institution delivering undergraduate construction management degrees. Post ethics approval, each respective Head of Department/ Discipline was contacted seeking their consent that staff and students take part. It was anticipated that across seven selected institutions there would be seventy-seven interviews (staff n=3, students n=5, associated industry/ sessional n=3 /per institution). Our final sample was fifty-two (Table 1). In addition a national advisory committee (NAC) of stakeholders (n=11) was also recruited and interviewed prior to and after the series of University interviews. For this type of research, it is suggested that the overall response rate is sufficient and generalizable data would be an outcome for the discussion section (Mertens, 2014).

Table 1: Participation

Institution	Staff	Student	Total	GO8	ATN
A	4	5	9	N	N
B	6	8	14	N	Y
C	4	2	6	N	N
D	1	0	1	N	Y

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E	1	3	4	Y	N
F	5	7	12	N	N
G	3	2	5	N	Y
Recent graduate	0	1	1		
Uni Total	**24**	**28**	**52**	**1**	**3**
NAC	11	0	11		
O/ll Total	35	28	63		

A student, staff/industry ethics pack was disseminated that included all essential documentation including; respondent's informed consent, willingness to participate and a specific interview protocol developed from the literature review. The industry focus group/ advisory committee was interviewed post this activity in order to provide a sense check of both the material sourced and the specific focus of the research questions. In parallel to the literature review being undertaken each participating university was asked to provide detailed information of their degree programs. This included unit/course outlines, details of assessment and both institutional and local learning outcomes/ objectives. At this juncture a proposed framework of resilience was created. The sample was determined, contacted and interviewed at their respective university over a period of two months. At the meetings, which were all digitally recorded, notes were taken which in combination allowed comprehensive transcriptions/ audio to be entered into Nvivo©. Following this, nodes were created that highlighted themes and these in turn were cross-referenced between institutions and scrutinised against the proposed framework. A summary presentation was presented to the industry focus group/ advisory committee as part of the action research methodology determined at the outset of the research. Finally, comparisons were made with the literature sourced and the final framework for resilience was developed.

DISCUSSION & OUTCOMES

Table 2 identifies the resilience framework themes and some of the project findings. A range of findings against each of the identified framework themes is given, with student comments selected from the face to face interviews that best illustrate the findings. Evidence indicates that the explicit introduction of resilience themes in built environment curricula of the universities involved in this project varies significantly. A number of students indicated that they received no "resilience education" and were unaware of curriculum interventions to address their capacity to "cope" in industry. Other students were able to identify examples of resilience "training" they had undertaken during their degrees that they were able to translate into "coping" mechanisms in the industry. When further probed at interview a number of students did in fact undertake similar activities, but were unable to appreciate the role of such learning activities in building their own personal resilience. Evidence from the students indicates that the

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resilience required to work in large, complex and stressful construction environments is not explicitly addressed within any one subject area, which may in itself contribute to students feeling "under-prepared" for industry. Yet conversely, the evidence also reveals the implicit use of learning activities within the curricula that address resilience themes across a range of subjects, such as personal time management, signposting, capstone project, group work, reflective practice covering specific attributes, industry experience, working on site, site visit, internships, part-time work before graduation etc. The prevalence of such learning activities across a range of subjects/ courses and the inbuilt resilience activities may not be immediately obvious to students, but it is clear that such activities are frequently tackled and undertaken in a number of teaching areas in built environment education. Such results indicate the need for explicit use of resilience activities to aid students' own personal growth in resilience and to create an explicit area for built environment academics to build upon. Upon reflection of the literature and the project findings, this study has identified five key explicit steps to develop resilience skills in construction management students;

1. Identify and incorporate different levels of resilience themes in several CM courses by the year of attendance and acknowledge resilience as one of the learning outcomes or attributes of the CM degree.
2. Develop and re-design identified course assessments considering resilience research, for example, emphasizing communication, verbal presentation, group work or role plays and provide sessions with industry experts.
3. Introduce the concept of resilience early, reinforcing the benefits of resilience and consequences of negative outcomes. In addition, students should be asked to identify and reflect on the antecedents, protective and risk factors and their consequences on individual cases along with assigned mentors. A day-long workshop in year 1 and year 3 would improve resilience significantly.
4. Develop support mechanisms to encourage students and graduates to become better acquainted with resilience. For example, junior students consulting with senior students and academic mentors whereas senior students and graduates could solicit advice from alumni.
5. Examples and case studies should be developed and taught considering the context of CM program and university culture and perspectives of student and academic staff cohort. Case study solutions may be established through reflection of engaged parties along with experts' recommendation.

In response to the five steps identified above a resilience "toolkit" for built environment educators to adopt and explicitly promote to students and graduates, is developed. The Toolkit for Resilience, a key outcome from this research, has been prepared for dissemination via web link and limited hardcopy to the membership of AUBEA. The toolkit describes the research undertaken, catalogues the information collected, identifies a number of courses where the use of the toolkit for resilience would be appropriate and

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presents a series of case studies that are useful for academic staff in the various units/courses that reside within a typical undergraduate construction management program. Parts of the toolkit have been utilised in the discourse of the research presented in this paper with acknowledgement to the Office of Learning and Teaching that supported the research.

CONCLUSION

The capacity of built environment graduates to perform effectively in the Australian construction industry is based upon a number of factors. One key factor is their ability to adopt resilient behaviours in a stressful, complex and often emotionally challenging environment. This study has identified a number of resilience themes that underpin the building of skills in resilient behaviour for construction graduates and sought to determine the prevalence of such themes in the curricula of built environment degree programmes in Australia.

The perception by students and industry that the development of resilience skills is not included within units of study in built environment degrees has been shown in this research to be a product of the "explicitness" nature of learning activities. Emerging evidence from students, staff and curriculum audits in this study suggest that there are many opportunities for resilience learning within built environment curricula, although unequivocal detail around resilience as a learning outcome needs to be built into the curricula. Adaptation of existing resources may also be required and evidence from student interviews suggests that an academic with a balanced career path, comprising both industry experience or industry contacts to draw upon, together with academic standing appears to provide a learning experience best suited to incorporate resilience behaviors and requisite training. Finally, the study has produced a "Toolkit for Resilience" that includes resources for use in the built environment curriculum. The trialing of this toolkit will inform future studies and enable greater depth of analysis of resilience in construction, thus producing longer term benefit to both graduates and the wider Australian built environment industry.

LIMITATIONS

In the interviews to ensure anonymity, no demographic details were collected and it is suggested the perceptions of a first year student may differ to some degree when compared to a fourth year students, this may impact the generalisability of the findings. For the future it is proposed that a more comprehensive quantitative survey be undertaken to test the framework described in this research and further validate the toolkit for resilence.

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Table 2 Resilience Themes	Findings	Relevant Comments from Interviewees
Antecedents are events that occur prior and affect an incident (Windle, 2011)	Personal and Family incidents, Assignment submission deadline. General perception of work-life balance.	*"Resilience was overlooked… there was a lack of training through my course… more would have been good".*
Protective factors protect those at risk from the effects of risk factors; individual, social, community/ society (Windle, 2011), (Tusaie & Dyer, 2004), (Fuller, McGraw, & Goodyear, 1999)	Capstone, problem solving, site visits, case studies, role play, group work, learning soft skills, mentoring, pastoral care, study plan, signposting, industry experience, work Experience, negotiation skill, knowing who to ask, train students to know when to release pressure, emotional intelligence, Support networks at University, Discussion on time management, Course scaffolding and incremental learning,	*"The people around me are the most useful tool that I have… talking with my managers and having open and honest communication with them about fatigue (for example)". "At Uni there is no real training to help you learn this…"*
Resilience - behavioral, attributional or emotional responses to the shocks and challenges graduates would inevitably face upon entering the construction industry	Balancing tensions, psychological well-being, maturity, life balance.	*"Learning from staff with industry experience creates confidence in me… what I am learning is useful knowledge…these are sign posts of learning"*
Risk factors stem from multiple life stressors, a single traumatic event, or cumulative stress from a number of individual and environmental factors (Tusaie & Dyer, 2004)	Risks of going outside your comfort zone and challenging ideas, student overload, industry related stressors, working in groups, working as well as study, romantic involvement of students at certain age, poor performance, time management, not knowing who to ask causes problems, fear of saying the wrong thing, bad behaviours.	*"currently working long shifts… have a bit of a foundation and understanding on those stresses would have been definitely useful… really how it works at the moment is trial and error – you learn as you go, you may stumble - then you get used to (the stresses) and the (working) environment".*
Consequences are the end-points that occur because of the antecedents and attributes of resilience (Gillespie et al., 2007).	Mental health issues support for young professionals.	*"currently working long shifts… have a bit of a foundation and understanding on those stresses would have been definitely useful… really how it works at the moment is trial and error – you learn as you go, you may stumble - then you get used to (the stresses) and the (working) environment".*

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Comparing continuance commitment in a project orientated organization.

ABSTRACT

Organizational commitment is recognised as having a positive relationship with employee retention and performance, yet the nature of commitment in a project-orientated organization is unknown. Project orientated organizations are complicated by temporary teams, varying workloads and inability to guarantee future projects. To date, research in project orientated organizations treats employees as an homogenous body. Adopting a case study methodology, this research explored organizational commitment within a project organization, comparing staff within the organization. Employees were asked to complete an online instrument measuring affective, normative and continuance commitment. Analysis compared results from project managers, project staff and support staff. The research found that project managers reported stronger affective commitment; support staff reported the strongest normative and continuance commitment. The concept of self-investment by employees in the organization is explored as a possible cause of high continuance commitment amongst support staff. Project organizations can use this information to enhance their management of employees. It is important for an organization with project and non-project employees to understand and meet the needs of different roles. The research concludes that the projectification of organizations has wider human resource management and productivity implications and requires further investigation.

Keywords: Commitment, organization, project.

INTRODUCTION

Increasingly, organizations are adopting a project based structure, known as "projectification" (Bredin and Soderlund, 2011). Project orientated organizations are different to non-project organizations because of their varying workloads, temporary teams and irregularity of future projects (Turner, Huemann & Keegan, 2008). The nature of organizational commitment in an organization with project characteristics is unknown, yet commitment is recognised as having a positive relationship with employee retention and performance (Meyer and Allen, 1997). Therefore understanding the nature of commitment in a project organization is a pre-requisite to improving these desirable behaviours. Adopting a case study methodology, this research explored organizational commitment within a project organisation, comparing project and support staff within the organization.

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This paper reviews current knowledge in the field of organizational commitment. It explains the increasing popularity of project orientated organizations. Data comparing project managers' commitment to other staff within the case study organization is presented, before the discussion centres on the major theme found: continuance commitment in the organization.

LITERATURE REVIEW

Organizational commitment is often referred to as the measuring of employee's attitudes and behaviours (Morris, Lydka & O'Creevy, 1993). To measure organizational commitment Allen and Meyer (1996) developed the Three Component Model (TCM). Although it still relates to measuring attitudes and behaviours, they identified three types of commitment: affective commitment, continuance commitment and normative commitment. Affective commitment relates to whether the person chooses to work at the organization because they want to work there. It also relates to the employees connection to the values and beliefs of the organization (Allen & Meyer, 1990). Continuance commitment occurs where the employee works at the organization because of the perceived cost or losses associated with leaving, or because there are no alternatives to current employment (McGee and Ford, 1987). Normative commitment refers to whether the employee works at the organization because they feel obligated to have loyalty to their organization (Allen & Meyer, 1996). Ideally, an employee would have strong affective commitment with lower normative commitment and weak continuous commitment. Allen and Meyer (1996) found that employees with higher affective commitment and normative commitment were less likely to have an intention to leave the organization.

The trend to measure commitment has not decreased with time. This is attributed to the association between commitment and organization performance, the vast number of antecedents and outcomes, and the perceived continued lack of clarity around the concept of commitment (Suliman and Iles, 2000). Analysis of literature published between 2010 and 2014 shows breadth in application of commitment research, including moving into previously unexamined cultures such as the Middle East region (eg. Suliman and Iles, 2000; Yousef, 2002) and China (eg. Newman and Sheikh, 2012). Aside from cultural exploration, there continue to be opportunities to examine the nature of specific antecedents and outcomes of different forms of commitment, and the nature of commitment development (Bergman et al., 2013).

Continuance commitment is different to affective and normative forms. It is associated with external regulators of work behaviour (Meyer, Becker and Vandenberghe, 2004). Its positive relationship with productivity is doubtful (although this is reflective of local culture, as reported by Sulliman and Ilse's (2000) in research in Jordan), and it is thought to be

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an indicator of an employee's intention to leave; high continuance commitment should not be interpreted as a positive achievement. Three specific causes of continuance commitment are thought to include longer tenure in the organization, having value to the organization recognised and individual negative affectivity leading which is thought to lead to perception of few alternatives (Iverson and Buttegieg, 1999).

Since continuance commitment is reflective of the cost of leaving, it could be managed by above average pay, flexible hours and other fringe benefits which might make it very difficult for an employee to leave; however whilst the employee continues to fulfil responsibilities, they might not be performing at their best. Research suggests that benefit plans increase employee commitment and reduce intention to quit (Ayache and Naima, 2014). However, Ayache and Naima used the combined measure of commitment – the OCQ – in their research and are therefore unable to eliminate the possibility that the employer in their research was "buying" continuance commitment from the employees and that high commitment scores were false.

The nature of continuance commitment being influenced so strongly by external factors which are under the control of the employer has not been overlooked. Coleman, Irving and Cooper (1999) describe the importance of the external locus of control and Vandenberghe and Panaccio (2015) explored the role of locus of control in influencing continuance commitment. However the presence of these external factors cannot disregard the individual perception of a factor's value, which will in turn be influenced by personal variables. It is possible, then, that employees in similar roles might be influenced by similar variables such as career stage and family priorities.

There has been a shift in the 21st century, known as "projectification", in which organizations adopt structures which have co-existing and temporary parts (Arvidsson, 2009). Heumann, Keegan and Turner (2007) defined project orientated organizations as organizations that manage both internal and external projects; have an organizational strategy and a corporate structure that is designed for working on projects including project management teams. Employees within project orientated organizations have to deal with fluctuating workloads and uncertainties around future projects, locations, and roles. Due to these issues Turner et al. suggest that the requirements of HRM within project orientated organizations are different compared to non-project orientated organizations. They also highlight that there is a lack of research into the complexities of HRM in project orientated organizations. Bredin and Soderlund review HRM in project organizations (2011); they approach HRM systems as collective, configurational and complementary. All three forms recognise the different roles in a project-oriented organization: line managers, project managers and the influence of HRM designed for one role when directed towards a different role. A limitation of Bredin and

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Soderlund's HR quadriad is that support staff are not explicitly identified. Whilst their definition of the HR quadriad is that the four roles have an interest in common, and therefore the exclusion of support staff is logical because they do not share the same interest in projects, this research argues that there is still a role for support staff in project organizations.

Challenges in project orientated organizations include the promotion of work life balance for employees and career development. Issues with career development arise in project orientated organizations because often project members do not know what future projects are coming up after the completion of their current project (Turner, Huemann & Keegan, 2008). Hobday adds that project oriented organizations do not prioritise formal training and staff development (Hobday, 2000); again, it is unclear if this characteristic applies across the whole organization – if PMs don't get sufficient development, do support staff get any either?

Despite the added issues around project teams, project orientated organizations have been found to have a higher retention rate of staff compared to non-project orientated organizations (Turner et al., 2008). It is believed that this is because project oriented organizations provide their employees with more challenging work opportunities.

Whilst research into project-oriented organizations has progressed in the last 10 years from exploration and development of concepts, to testing of theories, all the research published to date relates to project staff in an organization. Van Emmerik and Sanders (2005) wrote that "previous studies that have examined the relationship between mismatch and employee outcomes for different groups of employees are sparse" (p.713). This research agrees: the nature of interaction of project and non-project staff within a project oriented organization has not been explored.

RESEARCH DESIGN

After extensive investigation into methods currently used in organizational psychology, the research adopted a case study methodology as an appropriate method from which to build a theory. Welch et al. (2011) review the four approaches to theory building from case studies; they describe Eisenhardt's (1989) and Yin's (2009) arguments for the role of case studies in developing a hypothesis prior to testing. Generalization of the theory is less important during this early stage. Since this research is exploring the possibility of a relationship between continuance commitment and job role that has not previously been investigated, a case study approach is considered suitable. Further support for the use of a case study method can be found in Yin (2009) who regards case studies as particularly useful where the data is collected from an environment which cannot be controlled by the research, as is the case here. The

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researcher is an observer of the organization and has no intention to intervene.

The case study organization was a Melbourne based high density residential construction company that had been operating for 28 years and has two departments: development and real estate. The development department has 43 employees who are responsible for designing, building and managing the construction of large apartment buildings in Melbourne. The real estate department has 22 employees who are responsible for marketing, sales and customer relations in order to sell the spaces within the large buildings.

Data was collected from employees via an online survey. Commitment was measured using Allen and Meyer's (1996) Three Component Model. In order to investigate any differences in commitment across the organization, employees were grouped according to their position as a project manager, a member of a project team, or support staff. The results were analysed using SPSS with the aim of identifying any potential relationships between commitment and role.

RESULTS

Of the 65 employees that were emailed the questionnaire, 35 employees responded. The data was analysed in two stages, stage 1 using descriptive analysis and stage 2 using t-tests to test the relationships between variables for significance. Three job roles were defined: project managers, project staff and support staff. Within the organization, project managers managed the implementation of the documented project, usually from a site office. Project staff were assigned a project to work on, which could mean they were in charge of design, documentation or customer relations for the project. Support staff were not assigned to a project but worked to support the administration tasks required for the general running of the organization; they were located in the head office.

The results of the analysis is presented by job role group: project managers (n=8), project staff (n=12) and support staff (n=15). Staff that completed the survey assigned themselves to one of the three roles.

The project managers had the highest affective commitment of 34.13, followed by support staff with 33.76 and the lowest being 33.25 for the project staff (see Table 1). There were large differences in the results between the roles when it came to measuring continuous commitment. Support staff showed the highest results with 38.27 followed by project staff with 33.33 and lowest from project managers being 29.88. Support staff had the highest score for normative commitment being 30.20, followed by project staff with 29.75 and project managers with 29.63.

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Table 1: Commitment

	Project Manager	Project staff	Support staff
AC	34.13	33.25	33.76
NC	29.63	29.75	30.20
CC	29.00	33.33	38.26

Initial examination of the data shows each of the roles has one form of commitment higher than the others. For project managers, affective commitment is the strongest form of commitment, suggesting they are emotionally engaged with the organization. For project staff, normative commitment is much lower than affective or continuance commitment, indicating a lack of obligatory commitment. Viewed in conjunction with the reasonable affective commitment result, this is a positive trend. Support staff reported a higher continuance commitment score than affective or normative commitment; this is initially thought to be a concern, since continuance commitment is indicative of remaining at an organization due to potential losses associated with leaving. It is not associated with an increase in productivity or retention.

Of the three forms, only continuance commitment reported statistically significant differences between the three roles. Cronbach's alpha co-efficient for internal consistency for continuance commitment was 0.764.

On the advice of Pallant (2004) an independent samples t-test was conducted to compare the mean continuance commitment scores for project managers and support staff. The difference was significant for project managers (M=29.88, SD=10.59) and support staff (M=38.27, SD = 7.19; t(20)=-2.421, p=.025). The difference between mean continuance commitment scores for project staff (M=34.1, SD=5.70) and support staff is not significant, although shows a similar trend to that shown between project managers and support staff.

Several items in the continuance commitment scale show a significant result when project managers and support staff are compared. The item "if I had not already put so much of myself into the organization I might consider working elsewhere" is of particular interest. This item has a significant difference between project managers (M=1.67, SD=.500) and project staff (M=3.00, SD=1.33; t(11.711)=-2.941, p=.013), project managers and support staff (M=3.67, SD=1.29; t(-4.420)=22, p=.000) and between all project employees (M=2.37, SD=1.212) and support staff (t(32)=-3.014, p=.005). Project managers scored this item weakly

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albeit with a greater standard deviation, compared to support staff who scored the item strongly.

A further item, "It would not be too costly for me to leave my organization in the near future" was also significantly different between project managers (M=3.0, SD=1.414) and support staff (M=4.40, SD=1.454; t(24)=2.453, p=.022). The results of this reverse item on the scale shows that project managers believe, more than support staff, that it would be costly to leave the organization.

The mean tenure of support staff was less than for project oriented staff which was also less than for project managers, however this was not significant. The only significant demographic difference in roles was the gender: support staff are more likely to be women. However there was no significant association between gender and continuance commitment variables.

DISCUSSION

The purpose of the research is to explore the nature of commitment in a project orientated organization, such that a theory around commitment in a project orientated organization could be proposed and tested in later research. With insignificant results, it is not appropriate to suggest a theory relating to affective or normative commitment. However the presence of a significant result for continuance commitment warrants further exploration.

The results noted the significantly higher continuance commitment for support staff than for project managers. Continuance commitment scores are underpinned by the perception that there are few alternatives to the current employment situation, and by the perception that leaving the current organization would be costly in terms of losses. One conceivable cause which might fit with the different job role of the two groups is the locus of control theory. Coleman, Irving and Cooper (1999) found continuance commitment to be positively associated with an external locus of control. Support staff might perceive that the benefits they receive are a result of an external control. Vandenberghe and Panaccio (2015) find that locus of control only has a moderating impact on the costs of leaving sub dimension of continuance commitment, not on the perception of alternatives. They also associate the sense of impact (ie. the employee's ability to influence decisions in a work context) with locus of control, and this research supports this notion. In our case study organization, project managers might be more likely to have a greater sense of impact at work, thus bringing the locus of control internally and this has the effect of lowering continuance commitment. There is evidence to support this notion: project managers reported the highest influence over their job compared to the project orientated staff and support staff.

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They also reported the highest satisfaction with the amount of influence they have over their job.

The discussion will explore the two continuance variables with significant results: "If I had not already put so much of myself" and "it would not be too costly".

If I had not already put so much of myself into the organization I might consider working elsewhere

The continuance commitment variable "If I had not already put so much of myself" suggests the respondent feels they have given themselves to the organization, or invested themselves in the organization. Meyer and Allen describe continuance commitment as a result of a combination of the size and number of investments (ie. time and energy) made (Meyer and Allen, 1990). It seems logical therefore to refer to this item as the self-investment item.

The results showed that the support staff perceived that they invested themselves in the organization, and that project managers perceived they invested relatively little of themselves in the organization. Self investment is not a common phrase in the organizational psychology field. Faunce describes self investment as "a commitment to an activity based on the relevance of that activity for self esteem" (2003, p.4). His model shows individuals will tend to increase the self-investment they make towards their employing organization only where they see an increase in self esteem as an outcome, and where self esteem is a valued concept. Although support staff score this item highly it does not indicate that this group of employees actually do invest themselves in the organization. However it might indicate that this group of employees perceive that they do. The perception of self-investment in your employing organization is relative to how much you expect to self-invest; perhaps this group did not expect to invest themselves in the organization, but since they have done, they perceive this to be a strong investment. Whereas the project managers always expected to self-invest in the organization – maybe because their role is more senior, and also because they recognise that the profitability and success of the organization relies, in part, upon the project managers successfully completing projects. Since they expect to self-invest, maybe they don't rate it such a strong item. If we have no expectation to give, then a little sacrifice might be felt as a large self-investment.

If this explanation were to be further investigated and found to be true, expectations about self-investment might play an important role in continuance commitment.

It might be asked if self-investment is related to gender or tenure in this sample. This might suggest that female employees have different

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expectations relating to self-investment than male employees, or that they have different priorities such as family responsibilities. Given Faunce (2003) relates that greater self-investment occurs where self esteem is important, a female employee with family duties for whom self esteem is unimportant might perceive small sacrifices to be large self-investment, thus influencing continuance commitment. Unfortunately, the data provided no evidence to suggest that gender or tenure are significantly related to this continuance commitment item. Meyer, Allen and Smith reported in 1993 that this item reflected the time spent at the organization and the employment status achieved. However there was no significant relationship between tenure and continuance commitment. This research does not disagree with Meyer et al, but is unable to provide evidence to support the link between tenure, status and self-investment. In fact, Meyer et al. don’t mention that perceived self-investment could be influenced by personal factors outside the organization.

It would not be too costly for me to leave my organization in the near future

The second item to report a statistically significant result was “It would not be too costly for me to leave the organization in the near future”. This item reported a higher mean for support staff than project managers. Interpreting this result, it is suggested that support staff feel they have less to lose than project managers feel they would lose, if they left the organization.

Factors to consider as causes of this result are the nature and quantity of benefits offered to staff, and the ability of an employee to receive the same benefits at another employer. Also, where self-investment is an internal regulator of work behaviour, the costs associated with leaving the organization is an external regulator, although the strength of the control is moderated by an individual’s values. Therefore an additional consideration is the value placed on these benefits by the employee.

The potential losses or costs of leaving are understood to focus on the tangible benefits paid in addition to basic salary. These may include superannuation, company car, health insurance, professional development and a formal career path within the organization. The results suggest that project managers get more benefits than support staff, and that these benefits are associated with tenure at the organization and are not transferable; if they left they would leave the benefits behind. Alternative explanations are that all staff receive the same benefits but support staff value them less, or that support staff are the recipients of different benefits that are transferable. Since the research aimed to compare commitment scores, the actual benefits awarded to employees were not investigated.

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CONCLUSION

This research explored the nature of organizational commitment between employee groups in a project orientated organization. Affective and normative commitment were not found to experience significant results, but continuance commitment was significantly higher for support staff than for project managers. Two specific items on the continuance commitment scale were significantly different between project managers and support staff. The research explored the concepts of locus of control, self-investment and the provision of benefits as factors causing the difference.

This research supports the initial findings of Vandenberghe and Panaccio (2015) into the role of locus of control as a moderator of continuance commitment. The research found that different groups of employees perceive a different experience of self-investment, impact at work and perceived alternatives, simultaneously with experiencing different needs. These combine to demonstrate different levels of continuance commitment. The question must be asked if this is a unique finding in a project orientated organization, or if all organizations experience this difference between job roles to some extent? Perhaps projectification exacerbates the different experiences of groups of employees. Future research should consider comparing these findings with other organizations of various structures, including project orientated, to test the theory that employee groups experience significant differences in commitment and possible explanations.

Limitations of the research are that data were collected from one organization and the findings are not intended to be generalizable. The data collected was a single stage approach so explanations offered here are not able to be supported by empirical evidence; that is the role of future research.

In spite of the limitations the value of this research is twofold. Firstly, this organization presents as one which is in danger of losing support staff which will reduce the efficiency of the projects implemented, and will require significant investment of time and money in recruiting and training replacement employees. The organization would benefit from supplementing the quantitative data collected with further conversations regarding employee commitment and what can be done to improve this should it be thought a problem. Secondly, the general value to the academic community is that it has been made clear from the statistically significant results, that groups of employees (according to job role, or function in the organization) cannot be treated as if they have the same needs. Further, Vandenberghe and Panaccio (2015) point out the obvious practical implications of any research into commitment: knowing what influences commitment facilitates an organization managing it proactively through interventions delivered to the right people at the right time.

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Factors driving global outsourcing of materials for the Australian construction industry.

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Abstract

The Australian construction industry sources products from overseas to obtain a local cost-competitive advantage however it faces barriers and negative risks with this strategy. This study of seven successful Melbourne based importers of construction products found that they shared many of the same drivers, benefits and barriers reported in the literature, developing their own mitigation strategies to combat the risks. New factors identified but not previously reported were the inept behavioral practices of local suppliers compared to the ease of doing business and the superior ethical business practices of overseas suppliers. This suggests that local suppliers would struggle to meet the standard of service set by their overseas competitors.

Keywords: offshore sourcing, construction products, risk mitigation

Introduction

In the 1990's the Hawk-Keating government axed import tariffs and floated the Australian dollar to boost productivity and to make Australia more competitive (Jericho 2013). This allowed Australian importers to source products of similar or higher quality from overseas at lower prices (Jericho 2013).

Concurrently countries within the region: ASEAN states, Korea and China were becoming mega-manufacturing hubs, commencing global trade with the comparative advantage of abundant cheap labour (Brockwell 2008). This global market penetration was further enhanced by the advances in information technology, logistics cost reduction and the transfer of first world technology and knowledge to these developing countries (Baldwin 2006, Baldwin & Venables 2010).

International trade is generally regarded as beneficial but fraught with risks (Braithwaite 2003). Wang, Singh, Samson and Power (2011) found that of thirty-five Australian manufacturing companies importing products from China only seven had been sourcing from abroad for more than five years, suggesting that international sourcing by Australian companies is a relatively new phenomenon.

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These companies cited cost reduction and increased competitiveness in the local market as the main reason for adopting this strategy. However many found a number of negative consequences associated with these activities; unanticipated costs, quality issues, overseas government regulations and the possible loss of intellectual property (Platts and Song 2010, Jiang and Tain 2009).

The Australian construction industry contributes 7.3% to the gross domestic product (GDP) of Australia or approximately AU$200 billions annually (Crossley and Thomson 2013). The industry is predominantly dependent on domestic suppliers and manufacturers for its inputs, however, in recent years Australian companies have sourced steel, electrical, glass and aluminum products, lighting products, paint, glue plasterboard and engineered wood, from abroad (Crossley and Thomson 2013).

In 2011-12 approximately 11% of all construction materials were sourced from overseas (Toth, Richardson, Lim, Lill, Dowling and Walker 2012) and it is estimated that this will grow to about 15-20% by 2023 representing more than AU$30 billion of imports (Chandler 2012).

Crossley and Tomson's (2013) survey of the Australian Industry Group members found that 92% of the study cohort reported problems with product quality and products not meeting Australian standards. The Construction Forestry Manufacturing and Engineering Union (CFMEU 2015) reported anecdotal evidence that imported building façade had failed after installation.

This study sought to investigate the growth of importation of products and materials for the construction industry in Australia through the experiences of companies that have, on average, conducted this global sourcing for 18 years. The impetus for this has been the rapid growth of this phenomenon in the construction industry and the dearth of information pertaining to its value and its risks.

Literature Review

The Price Waterhouse Coopers (2007) report on global construction and engineering found that ten percent of engineering and construction products could be sourced at low cost from manufacturing countries in Eastern Europe, Latin America, China and India, where savings of 30-38% were possible. Savings of this dimension compared to domestic sourcing, provides firms with a competitive advantage (Kotabe and Murray 2004). This is consistent

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with the findings of Nassimbeni 2006 and Wang et al 2011 who found that cost was the main driver for offshore sourcing. Despite this, the total cost of the endeavor allowing for the complexity, uncertainty and negative risk of offshoring feasibility must also be considered (Trent and Monczka 2005). Bruce, Moore and Birtwisler (2004) categorized these sourcing activities as push or pull factors. The push factors, included: shortages in the local market, the inflexibility and inefficiencies of local suppliers, while pull factors were the superior technology and product reputation of the overseas product.

Offshore sourcing has both positive and negative risks. Positive risks are those with the potential for lower costs and higher quality (Howeg, Reichhart and Hong 2011, Wang et al 2011, Nassimbeni 2006), while negative risks include the consequences of different legal systems, culture, language and supplier issues in the sourcing country (Platts and Song 2010, Jiang and Tain 2009). These risks are due to managements' bounded rationality and uncertainty threshold when evaluating an offshoring policy (Williamson 2010).

Holweg, Reichhart and Hong (2011) have suggested that firms who are contemplating an offshoring policy should employ a 'spider chart' as a tool to assist with decision-making. The arms of the web could include various risk factors such as: lead times, demand uncertainty, cost of lost sales or obsolescence, supply chain problems, and unsatisfactory quality due to product complexity. The area of the web would determine if overseas sourcing outweighs the risks involved.

There is limited information regarding offshoring-sourcing activities in the construction industry within Australia. Wang et al (2011) surveyed thirty-five Australian manufacturers that sourced materials, components and finished products from China. The study found that the primary motivation was cost reduction. However, expectations were not always meet. The study identified sourcing difficulties such as dealing with a foreign government, hidden costs, loss of intellectual capital and quality problems. Crossley and Thomson (2013) similarly found that the quality of products as well as non-compliance with Australian standards were negative outcomes of offshore sourcing. This lack of quality and non-compliance with Australian standards has also been reported by the CFMEU (2015). However it should be noted that these CFMEU reports are anecdotal.

Research methodology

The qualitative methodology employed was an exploratory empirical

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inquiry of seven case studies of importers of construction products. Participants were selected from a list of fifty importers of construction products. Of the fifty contacted, seven agreed to participate in the study. The participants included the following importers of construction products: Timber, stone, steel sheeting, structural steel, tiles, kitchens and computer cabling. The data collection method took the form of semi-structured interviews lasting approximately 35 minutes. A senior manager in each company was interviewed. All interviews were digitally recorded for transcription purposes.

According to Yin (2014) the case study method describes a contemporary phenomenon in a natural setting where data points are the technical distinctions for each case rather than specific quantitative variables needed for statistical analysis. The comparative case studies were chosen to present an interpretive exploration of the cohort's experiences regarding the drivers to import, the risks faced and the mitigation strategies used when importing construction products.

Individual case study transcripts were analyzed thematically adopting the method of Braun and Clarke (2006) and Boyatzis (1998) where patterns and ideas within the data, through textual analysis, were systematically coded to qualitatively inform the key thematic aspects.

The interviews encompassed five themes drawn from previous studies. These were:

- Motivation - what drivers led the firm to source product from overseas.
- Positive risk – what factors supported overseas sourcing.
- Supplier risk – what supplier issues were revealed
- Supply chain risk – what logistics issues were exposed
- Financial and legal risk – difficulties associated with geo-political diverse systems

Results

The first theme motivation, found that responses related to; pricing, local demand not met, superior quality of overseas product or quality control of local product, lack of supplier diversity and poor range of local product.

The study identified three main factors: pricing and the lack of local supplier diversity and local un-met demand (Table 1).

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Response n = 7	Pricing Issues	Local Un-met demand	Superior brand O/S	Supplier behavior & practices	Lack of supplier diversity	Quality & QC of local product	Range of local product	Other
Number of case studies	**6**	**5**	**4**	**3**	**6**	**3**	**3**	**3**

Table 1. What led your company to source this product from overseas?

The second theme, positive risk identified; cheapness, local product not available or of limited diversity, better treatment or ease of doing business, superior technology or environmental practices, higher quality and more competitiveness as factors promoting overseas purchasing.

The study identified cheaper cost as a unanimous positive followed closely by the higher quality of overseas product and products not locally available or a wider range (Table 2).

Response n = 7	Cheaper	Product not locally available Wider range	Sourcing from multiple locations	Better treatment, ease of business	Superior technology or environmental practice	Higher quality and standard	Edge on local competitors	Other
Number of case studies	**7**	**5**	**3**	**4**	**3**	**6**	**2**	**3**

Table 2. What positive risk factors has your organization found with your sourcing activities?

The third theme supplier risk, revealed issues regarding; finding the right supplier, language and cultural barriers, quality and redress for faulty product and cost of fixing mistakes, differences in product standards and expectations, and reduced buying power of smaller local purchaser as experiences differing from local buying.
The study identified that finding the right supplier was very important along with issues of standards and ease of redress for faulty products (Table 3).

Response n = 7	Reduced buying power due to size	Language and cultural problems	Difference in product standards & expectations	Finding the right supplier and people	Quality	Ease of redress on faulty products	Cost of fixing supplier mistakes.
Number of case studies	**3**	**2**	**4**	**5**	**3**	**4**	**3**

Table 3. What supplier risk has your organisation experienced when sourcing overseas?

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The fourth theme, supply chain risk considered the logistics issues of; shipping delays, mediating agents, customs and industrial issues, damage in transit and forecasting as items of concern.

While not considered a major problem shipping delays and disruptions, forwarding and importing agents and transit damage to products were expressed as the main concerns (Table 4).

Response **n = 7**	**Shipping delays & disruptions**	**Forwarding & importing agents**	**Customs & industrial problems**	**Forecasting risk**	**Products damage in transit**	**Little if any problems**
Number of case studies	**5**	**4**	**2**	**1**	**4**	**3**

Table 4. What supply chain risk has your organization experienced when sourcing overseas?

The fifth theme regarding financial and legal risks concerned; currency fluctuations, dead stock, anti-dumping actions by local suppliers and the legal system of the sourcing country as items worth considering.

All study participants identified currency swings and exchange rates as important. The issue of "dead stock" was a concern to some participants but the occurrence of this was small (Table 5).

Response **n = 7**	**Legal system of sourcing country**	**Dumping actions by local suppliers**	**Currency swings**	**Legal issue of "Dead Stock"**
Number of case studies	**2**	**2**	**7**	**3**

Table 5. What financial and legal risk has your organization experienced while sourcing overseas?

Discussion

A number of findings confirm the previous studies of Holweg, Reichhart and Hong (2011), Nassimbeni (2006) and Wang et al (2011) noted that unit cost was the main driver for an import strategy. This was closely followed by the inability of local manufacturers to meet the range and/or supply the demands required by the local construction industry. Sourcing a range of products from a number of countries and suppliers gave greater

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flexibility, a greater range of product and therefore an edge over their local competition. The superior quality of overseas products and the lack of quality and quality control of local products were other drivers for sourcing overseas. However, the Crossley and Tomson 2013 study contends that almost every category of construction product imported into Australia had problems with product quality, sighting that 92% of their 222 survey respondents reporting substandard, non-conforming products. Both these claims may be correct as this study cohort was made up of successful and experienced long term importers, who over time have integrated mitigation strategies into their importing activity thus making sure that their products are of high quality and conform to Australian standards. The findings of Crossley and Tomson 2013 suggests that there may be many firms involved in sourcing that have not developed a network of reliable suppliers nor had they developed mitigation strategies to ensure a supply of product that conforms to Australian standards.

The lack of local supplier diversity was sighted as a driver and positive risk factor linking the inept behavior and practices of some local suppliers that have a near monopoly in the local market. The demise of manufacturing in Australia, cheap imports, small Australian market and high Australian dollar was also considered (Toner and Stilwell 2014).

In contrast to Wang et al (2011), who considered doing business overseas as having many negative risk factors, study participants reported the ease of conducting business and their treatment by suppliers overseas as a positive risk factor. This may be subjective based on poor experiences with local suppliers.

The major supplier risk reported was finding the right supplier and people to deal with. This risk factor is an obvious one, particularly when having to deal with language, culture and legal systems which may hinder due diligence of suppliers (Jiang and Tain 2009). In this study, participants mitigated this risk by trial and error over a lengthy period of time until appropriate suppliers were found.

Consistent with the findings of Crossley and Tomson (2013), differences in standards, product expectations and quality were experienced by study participants. However, these risks were mitigated over time by using the following strategies; finding the right supplier who was consistent with quality, standard and product expectation, manufacturing prototypes of the intended imports that were then tested in Australia using third party laboratories.

A number of supplier risks reported relate to the size and/or

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economic clout of the study cohort, including the ease of redress for faulty goods supplied, cost of fixing supplier mistakes and reduced buying power. Though these risks were deemed rare, no one suggested any mitigation strategies.

Jiang and Tian (2009) identified language and cultural barriers as an offshoring risk. However, the study participants mitigated this risk by employing individuals native to the country and understanding of the local culture.

Supply chain risk was not considered a major concern. Shipping delays and disruptions were the main supply chain risk experienced by the study participants. This was not deemed to be a significant problem, with participants reporting little or no shipping delays or disruptions. The improved logistical capabilities are consistent with the findings of Chopra and Sodhi (2004) and, Bygballe, Bo and Gronland (2012). Strategies employed by the study participants to mitigate this risk included; tighter control of the ordering system, forward planning using long lead times, carrying safety stock, and using insurance as a hedging strategy for 'acts of God'.

Dealing with forwarding and importing agents was reported as a concern and is consistent with the literature (Nibusiness info.co.uk n.d.). Mitigation strategies adapted by participants included; employing their own staff in the sourcing country or employing head office staff that were fluent in the language and culture of the forwarding agents.

Goods damaged in transit, customs and industrial disputes were reported. Any extra costs were borne by the importer. No mitigation strategy was offered.

Only one participant experienced forecast risk and though rare, was a significant cost. This is consistent with Chopra and Sodhi's (2004) who listed this as a significant problem.

Financial and legal risks associated with overseas sourcing were not considered to be of major concerns by the study cohort. All participants considered currency swings (Jiang and Tian 2009) the most salient financial risk factor. For example, the Australian dollar over the last fifteen years has swung considerably against the premier trade currency, the U.S. dollar from US$0.5 in 2001 to US$1.10 in 2011 and then to US$0.75 in 2016 (Garton, Gaudry and Wilcox n.d., Desloires 2016). All case studies reported that this risk was well controlled by; using hedging to smooth out fluctuations, using worst-case scenario pricing, sourcing from a country with a favorable currency and dealing with large companies that can

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absorb currency swings.

Study participants highlighted two legal issues: the futility of legal redress for wrong stock sent and the corrupt nature of the legal system in some sourcing countries. The only suggestion put forward by participants was to develop a good relationship with suppliers so that these issues do not arise.

Conclusion:

Seven successful Melbourne based organisations were studied, identifying that sourcing of construction materials from overseas shared many of the same drivers, benefits, barriers and mitigation strategies experienced by other industries carrying out off shoring activities. A number of new factors and mitigation strategies were identified: the inept behavior of local suppliers acting as a push factor for local firms to source overseas and the surprising positive risk factors of the ethical business practices of overseas suppliers and the ease of doing business there compared to the local market. This is in direct contrast to what has been reported in the literature. Participants also reported the sustainable practices of some European suppliers as a positive risk factor that gave them a competitive edge over local suppliers.

The negative risks reported by study participants though rare, were the same as those previously identified in the literature. However, the study identified a number of practical, tried and tested mitigation strategies developed by study participants over many years. This included the hiring and involvement of staff from Australia’s diverse multicultural population to overcome language and cultural barriers in the sourcing process. The study also identified practical solutions to problems associated with quality that is the arm’s length testing of products at the expense of the importer to ensure that they conform to Australian standards and the alignment of Australian standards with international standards. The use of the Australian legal system to hinder the operations of local importers may well be a new barrier, previously not identified in the offshoring literature. However as only the importers side of the argument has been given in this study, this assertion needs to be studied further before any of these claims can be substantiated.

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This study had a number of limitations; the number of firms investigated was seven. This sample of firms does not represent a true cross section of all the construction industry participants and the firms studied comprised small to medium size enterprises. Nevertheless there are a number of areas worthy of further study. The risks associated with offshore outsourcing activities carried out

by tier one and tier two building companies, engineering services providers and architectural firms. Quality-testing regimes to determine if imported building products are 'fit for purpose' and the ineptitude of local suppliers.

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BUILDING STEM SKILLS IN BUILT ENVIRONMENT EDUCATION

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ABSTRACT

Australia is on the cusp of a range of global megatrends across technology, society, the economy, and the environment which are changing the world of work for future graduates beyond current recognition. Digitisation, technology and automation are requiring new *skills* at a rate of exponential change. Many of these skills have traditionally been classified as skills related to STEM disciplines. But future employability is now linked to the growing demand for 21st century STEM *skills* beyond existing traditional understandings of STEM. It will not only be STEM graduates who will need 21st century skills of discipline literacy, adaptive thinking, proficiency in coding and technology, utilising a design mindset, complex problem-solving and analytical thinking skills. All students, including built environment graduates, will need adaptive thinking about their worlds and exposure to 21st century STEM *skills and understandings*. This research work by members of the OLT funded STEM Ecosystem illustrates the development of STEM skill learning opportunities for built environment students. The learning opportunities discussed in this paper are archetypes of 21st century skills and featured engagement with diverse cohorts of students, practice-oriented learning, STEM literacy, adaptive thinking and discipline-based core knowledge. The results from 46 student interviews indicate the relevance of 21st century STEM skills for built environment students, and the increased skill set of built environment students involved. The results and outcomes of this research have the capacity to provide industry with built environment graduates who are not only technically skilled but future 21st century STEM work-enabled.

Keywords: 21st century skills, construction, employability, graduates, STEM.

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INTRODUCTION

Australia is on the cusp of a range of global megatrends that are changing the way people live, work and acquire knowledge. Megatrends across technology, society, the economy, and the environment are changing the world of work for future graduates beyond current recognition (CSIRO 2016). Digitisation, technology-fuelled disruption and automation are requiring new skills at a rate of exponential change. This disruption arising from the interaction of technological change and increasingly porous global boundaries is already creating a brave new world of work reliant upon 21st century STEM skills (Callander, 2015; Gratton, 2015). This disrupted future holds exciting opportunities for universities and their graduates, but also poses complex, urgent questions. To imagine the university built environment curriculum, with its current siloed approach and discipline-based teaching and learning, is immune from these trends is naïve.

The demand for graduates with *skills and understandings* that match 21st century workplaces is escalating (Montt, 2016; Productivity Commission, 2016). The term 21st century skills refers to a set of knowledge, skills, work habits and character traits that are critically important to success in today and tomorrow's world and workplaces (Siekmann & Korble, 2016; Binkley et al, 2012). Deloitte (2015) and West (2012) note the intrinsic overlap between 21st century skills and STEM skills and ways of thinking, and provide evidence that employment success across a wide range of current and future industries is related to 21st century *STEM ways of thinking* such as analytical skills; logical and critical thinking; systematic, structured understandings; evaluative approaches; independent reasoning with sceptical and evidence-based rational approaches to problem solving and innovative, creative and lateral solutions. The Organisation for Economic Co-operation and Development (OECD, 2014) has highlighted the supply of professionals with these skills, as an urgent global problem. This increasing global demand for graduates with 21st century STEM skills is a result of a number of factors, including:

- the growing use and impact of information and communications technologies inter-woven across all future work;
- the high rate of innovation fuelling rapid application of advances in multi-disciplinary products and processes; and
- the shift to more knowledge-intensive industries and services, not reliant upon single traditional discipline responses.

The traditional understanding of STEM has long been viewed as beyond built environment and focussed upon careers in science, technology, engineering and mathematics (Sanders, 2009; Binkley et al, 2012; World

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Economic Forum, 2015). However simply providing more STEM graduates in existing disciplines to the exclusion of other disciplines such as built environment will not address future domestic and global workplace needs, nor contribute to Australia's economic prosperity (OCS 2016). There is a growing demand for 21st century STEM *skills* beyond existing traditional understandings of STEM disciplines. It will not only be STEM graduates who will need 21st century skills such as discipline literacy, adaptive thinking, proficiency in coding and technology, utilising a design mindset, complex problem-solving and analytical thinking skills. All students, including built environment graduates, will need adaptive thinking about their worlds and exposure to STEM skills and understandings to navigate future employment. Evidence indicates that building 21st century STEM skills across the total population will be critical in helping to support innovation and productivity regardless of occupation or industry (PWC 2016). As Finkel (2016) noted, "**all** graduates need to be equipped with STEM skills to enable their futures in a changing world: STEM ***skills*** are needed for all jobs."

The Australian Government (OLT) funded STEM Ecosystem project (Mclaughlin et al, 2015) identified the need for *all* students, especially built environment disciplines to undertake opportunities to build their STEM cross-disciplinary skills. A key recommendation of the project was-

- That STEM skills and the involvement of non-STEM discipline students in cross-disciplinary projects and learning approaches be enhanced through practice-oriented, credit-based cross-disciplinary learning innovations, workshops, studios, challenges and courses (McLaughlin et al, 2015 p.9).

The project noted that effectiveness of impact upon lifelong learning is more likely to be achieved if students are exposed to these opportunities during their discipline-based studies. Such exposure lifts interest, understanding and creates a domino effect of change. Existing evidence indicates that non-STEM students engaging with STEM learning and teaching opportunities (even for short periods of time) develop their critical thinking, problem solving, analytic capabilities, adaptive thinking, quantitative analysis, imagination and curiosity skills, all critical skills in future workplaces (Freeman, 2013; Healy et al, 2013).

Healy et al, (2013) estimate that 44 per cent of jobs in Australia, many in built environment areas, are potentially at high risk of automation and computerisation and that many new jobs will also be created by technology. Australia is entering a period of rapid transition where STEM 21st century skills will be vital for employability and lifelong learning and satisfaction. The need to change learning and teaching approaches to match such future workplaces and identify clever delivery of 21st century STEM skills to all students, including built environment students, is now urgent.

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THE 21st CENTURY STEM SKILLS

The concept of 21st century skills refers to a comprehensive and grounded skills framework that displays all of the literacies and employability skills desired by employers and applicable to lifelong learning and futures in a globalised, changing world (Siekmann & Korbel, 2016). Binkley (2012) in an analysis of such frameworks noted the importance of *ways of thinking* as underpinning much of the framework. More recently the World Economic Forum (2015) grouped the 21st century skills into foundational literacies such as discipline literacy, and competencies and qualities such as curiosity, adaptability and critical thinking/problem solving. West (2012) describes 21st century skills as knowledge, skills and ways of thinking so that graduates can function in a "STEM-core" world.

Whilst the nomenclature of 21st century STEM skills is constantly refined, what is not under debate is that today's students need different skills from those taught to previous generations. Yet much of our teaching and learning still present in university curricula reflects pedagogy and discipline-based knowledge that is not encompassing of future 21st century skills. Skills such as critical literacies, initiative, technological literacy and adaptive design are essential to success in modern workplaces and adult life (Siekmann et al, 2016), yet are often buried within discipline–based contexts. As a result most students have little or no exposure to such skills in any developmental way and most students acquire such skills in an ad-hoc manner.

A number of researchers have linked 21st century skills and STEM skills as interchangeable (Binkley et al, 2012; World Economic Forum, 2015). The concept of STEM has a number of meanings, but STEM itself is now recognised as a meta-discipline in its own right- the integration of formerly separate disciplines into a field of study that embraces 21st century skills (Blackley et al, 2015; McLaughlin & Kennedy, 2016). Lantz (2009) refers to STEM as a "discipline created on the integration of skills and knowledge into a new whole" and talks of a pedagogical approach of STEM that is of purposeful design and inquiry, combining technical design with inquiry to acquire 21st century skills. Whilst there is still a place for the existing discipline-based approaches, as Williams et al (2013) note, the pressing need for an integrated approach that positions all students and learners for employability and learning futures is escalating. This paper illustrates how built environment students can access 21st century STEM skills in a cross-disciplinary team environment.

The relevance of 21st century STEM skills for all students cannot be underestimated in an age when vast quantities of information are available instantaneously and outdated almost immediately, the ability to deal nimbly with complex and often ambiguous knowledge is far more important than an accumulation of facts. In a flat, connected world, built environment graduates will need the cultural awareness, and global

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contacts essential for a global market place (Navitas, 2013). As Barber et al (2013) indicate, most graduates will either work in an international company or spend part of their career overseas – to be global business savvy, to be culturally competent, is no longer a 'nice to have', it's a competitive advantage.

These imperatives are not for selected STEM disciplines: they are for **all** students. All built environment students need to have at least some experience in cross-disciplinary practice-oriented 21st century STEM learning opportunities to develop these skills and competencies. The following section discusses the incorporation of built environment disciplines into 21st century STEM skills learning opportunities.

DEVELOPING 21ST CENTURY STEM SKILLS in BUILT ENVIRONMENT LEARNING

Built environment disciplines are often seen as opportunities to induct students into the content of the discipline, not as opportunities to develop cross-disciplinary skills or develop solutions to complex multi-disciplinary problems using 21st century skills. Whilst there is a place for specific discipline-based education, it is not the only type of education students of the future should be offered. What is required is the application of STEM skills and ways of thinking to multidisciplinary understandings and solutions. A paradigm shift away from discipline-based knowledge transference towards 21st century STEM skills for the future (Kennedy & McLaughlin, 2016) encompasses -

- cross-disciplinary understandings/competency
- discipline "literacy" skills
- social intelligence
- STEM design mindset
- sense-making/adaptive thinking
- cognitive load-management
- ways of thinking (problem-solving, critical analysis, creativity, innovation)
- ways of working (collaborative, communication)
- ICT literacy
- Citizenship (global competence and cultural responsibility)

The Sustainable Systems Course at RMIT (MIET 2380) created opportunities for students from different discipline-based degrees (engineering, health, education and building) to work alongside industry practitioners in cross-disciplinary teams to design, present and build (in 2018), innovative sustainable sanitation solutions for the Yasawa communities in Fiji.

The course was conducted in semester two, 2016 and built upon existing STEM Ecosystem work in the College of Science, Engineering and Health

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at RMIT. A total of 46 students from engineering, built environment, education and health disciplines enrolled into the course. As a cross-disciplinary course, all students received credit for either elective or core course study. Students were given the project brief and information by the industry people in the Yasawas, Fiji, including Barefoot Resorts. They worked in project teams to create and discuss potential solutions, and checked their ideas against the industry people via skype and email. The nature of the project required 21st century STEM skills with discipline-based literacy and content input provided by the students and cross-disciplinary problem solving, critical analysis and creative innovation. The aim to build cross-disciplinary understandings, 21st century skills and global competence was also introduced during classroom sessions.

The students and staff set up a Google site and drop box, which were used as a virtual “meeting place” and “exchange”. Evaluation and feedback was built into the learning process, with set time devoted each week to evaluation of the design and development processes and a particular 21st century skill session related to the Fiji project conducted each week at the commencement of the class. This opportunity for reflective practice enabled students to organize their learning and ways of working to include collaboration and feedback. It also allowed for adaptive thinking around the problem and learning from their peers or “sense-making” of the issues.

The course was conducted in two workshops each week of 2 hours duration for one semester. Students came from diverse discipline backgrounds with differing levels of knowledge and skill. Classes were built around 21st century skills development: problem-solving, adaptive thinking, critical analysis, STEM design and literacy, and social and emotional intelligence. The majority of the students, and all of the built environment students were in the second year of their studies. Students who participated in this course have the opportunity to travel to Fiji under Endeavour and NCP grants to collect further data, build their ideas in practice and participate in local community activities in 2018/19.

At the conclusion of the course, all students were interviewed in their teams about their experiences and understanding of 21st century STEM skills and their ability to build such skills in their team project. A total of six questions were asked of each group.

One of the key 21st century STEM skills that the course aimed to develop was discipline literacy and STEM design mindset- that is using all the skills of the team (engineering, construction, health and education) to design a solution. Students felt the opportunity to engage with other students strengthened their discipline literacy and depth of discipline understanding. Comments included:

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“When I had to explain the water table and the depths to others who didn’t understand it, I realised I had to use examples that they would get- that was hard and forced me to think about engineering differently”

“Well, the construction guys all knew things that I didn’t, maybe their background, so I actually had a bit to learn from them really- so it was good“

This construct of STEM literacy is multi-faceted and includes the development of competencies for lifelong learning, including an ability to engage in reasoning about complex societal issues (Sabelli, 2006). Students interviewed in this course agreed that they were required to reason in their discipline to advance the team thinking:

“Basically you need to listen to others and their arguments to get the results. None of us alone could do this- really X (the education student) was able to get us to say our own view from our own background, like engineering, and then we sort of listened to others and made some better answers from that.”

“Really I knew nothing about health or building and now I do!”

A critical 21st century skill is *ways of thinking* (problem-solving, critical analysis, creativity, innovation) that advance the students along a continuum of learning. Siekmann et al, (2016) indicate that such a learning process provides a training ground for future workplaces and employment. There is evidence that providing diverse disciplines with opportunities to work together allows innovation and creativity:

“I wouldn’t have thought of what the health student did- I was like- really, is that true, because we had better put it into the answer”

West (2012) describes 21st century skills as knowledge, skills and ways of thinking so that graduates can function in a “STEM-core” world. He describes future workplaces as being places of STEM-core work that requires research, enquiry; problem solving; technical skills including observation, experimentation and quantitative skills; presentation and teamwork. All students need to be exposed to these STEM core skills beyond their discipline. When asked about their contribution to these skills areas the construction students felt they had learnt new ideas, skills and thought processes, and had contributed to others understanding and appreciating their role:

“It gave me some skills in experimenting with solutions, like the sand filtration set-up. Then we didn’t use it, so I guess I learnt a lot about planning and experimenting and yeah, some technical science/engineering skills. I mean I am not an engineer, but now I have some clue about what they could help with and help the answers.”

" Yes, I definitely learnt some new skills like you say "stem" but really it was just that they were able to let me have some ideas that we could trial out." Students were experimenting and developing technical thinking skills beyond their construction discipline as detailed by West (2012) in his analysis of STEM-core skills.

Freeman (2013) also indicated that even some small exposure to STEM skills and ways of thinking would create change in thinking amongst non-STEM students and the student interviews in this course supported this:

"I guess my frame of reference changed, when I realised I had to learn some new things and I just couldn't design the answer all alone- I needed the engineer to help, especially with the drawing parts. I definitely changed my ideas and thinking"

The concept of 21st century skills also includes ways of working collaboratively and with developing social intelligence. When asked about their team's maturity and performance, students noted the growth in stages of maturity:

" At first, everyone just put forward their ideas and some people did not accept the skills of others, then as the course went on we learnt new things and changed our behaviour I guess"

" I wasn't sure of my team- like I thought it would be helpful to put all the building students in one group at first, but that may not have worked."

Both Navitas, (2013) and Barber et al (2013) have stressed the importance of students tackling complex problems that are beyond their current discipline and which represent a wider world view than the domestic applications. By providing such a problem as the sanitation issues in the Yasawas, students were unable to draw upon local knowledge and had to design creative and adaptive ways of accessing global information not readily available.

"Of course it is important to help others, but it is not just helping- we are learning too"

"Who really cares about Fiji- I wonder if we should look at problems here in Australia….easier for communication and information"

Lantz (2009) refers to STEM as a "discipline created on the integration of skills and knowledge into a new whole" and Sanders (2009) talks of a pedagogical approach of STEM that is of purposeful design, combining technical design with scientific inquiry to acquire 21st century skills:

"This was great- learning new things that you wouldn't get taught in building classes"

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"I have learnt so much about engineering and technology, and maybe thinking about design all the time when getting the answers."

Williams (2011) has noted the pressing need for an integrated approach that positions all students and learners for employability and lifelong learning futures, whilst acknowledging the need for discipline based knowledge to fuel discipline literacy. In this study students were very aware of this future "learning":

" I think this will help me get a job- I am able to work with engineers, health students and education students on a shared project that will probably be built in Fiji in 2018-2019, so that is great for me. Plus, I have a whole new idea of what these others can do and really they were able to do things that I couldn't do, so that was very useful….if you only do it from your perspective, then that doesn't take into account things like health of the people there"

The proliferation of technology and increased global interconnectedness is forcing employment changes to enable further flexibility and virtualisation of the workforce. The Oxford Martin Commission for Future Generations (2013) suggests that graduates desire for full employment in their chosen discipline such as built environment areas may require revision. They cite evidence of movement towards a more fluid employment relationship, with individuals holding portfolios of skills that match work activities, including adaptive thinking, disciplinary literacy, STEM competencies, quantitative thinking skills etc. As one student noted:

"I am definitely more motivated now and can see this being of benefit to my future jobs- there are things that I learnt here, like explaining what the structure should be built like, that I was able to show I knew something and then to get ideas from the others about making it happen. That was an important skill I think"

The course had a total of 42 students, of whom about 20% were built environment students across the second year of their AQF 5 studies. This indicates the limitations of the results, given the small sample size, the stage of the students' studies and the elective nature of the course. However, the evident change in skill development through the exposure to 21st century STEM skills as self-reported by the students in the interviews, indicates benefits and obvious advantages for built environment students.

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CONCLUSION

The benefit to all students of a flexible, relevant, 21st century STEM skill learning opportunity is immeasurable. In a growing competitive market, the learning and teaching opportunities and experiences provided to students are becoming increasingly critical to the future of universities.

Graduate lifelong learning and employability is at the heart of university business. Built environment students in this course benefitted from an informed, flexible, industry-relevant pedagogy built upon 21st century STEM skills that matched their experiences of a globalised world. Whilst there is still a place for the existing discipline-based approaches, as Williams (2011) notes, the pressing need for an integrated 21st century STEM skill approach that positions all students and learners for employability and lifelong learning futures is escalating. The results from students in this sample indicate that students themselves are aware of the value of such integration. To enable all students and remain competitive, built environment disciplines must examine 21st century STEM skill learning opportunities to acknowledge potential for improved activity in current curricula. The challenge is clear and exciting.

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INTEGRATING INTERDISCIPLINARY THINKING AND PRACTICE: A CASE STUDY OF A VICTORIAN UNIVERSITY IN AUSTRALIA

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The value of interdisciplinary approaches to curriculum have been considered successful along multiple fronts; including reducing administrative burden from inter departmental collaboration, providing "intellectual" solutions to problems and breaking academic discipline boundaries. Criticism from industry often focuses on educators not preparing graduates for work in the real world. A major reason underpinning this criticism is that the students are not exposed to the requisite skills to make them work-ready. Despite the pressures to include interdisciplinary approaches from an ethical perspective, putting it into practice is difficult. This paper presents the findings of involving students from three different schools in a Victorian university in Australia: built environment, business and computer science. The project was developed as part of a state government competitive fund where industry, staff and students worked together to support each other and realize mutual benefits. The aim of the study was to develop an approach involving students in a theory-practice model of a real world project by selecting a building within the university as a case study to arm students with real world knowledge focusing on sustainability outcomes. The objective was to assist in preparing students from different disciplines for better workplace experiences, where they can bring in interdisciplinary thinking and practice into their day-day operations. The outcomes for the university, in using this building as a living laboratory, was to capture lessons learned through the process of improving future building developments from a sustainability perspective. Student involvement was successful, but true interdisciplinary engagement was not achieved.

Keywords: built environment, students, inter disciplinary, collaboration, curriculum

INTRODUCTION

The aim of interdisciplinary teaching is to provide real world context for delivering the aims of education. This is underpinned by the knowledge that establishing good working relationships are critical for any project success, leading to greater client satisfaction and a more positive experience for all disciplines.

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This project sought to bring students from three disciplines: Construction Management, Business and Information Technology, and Computer Science to work on a common project for student engagement as part of their learning journey at the university with a view to exposing them to the real world context and explore interdisciplinary engagement and understanding in the process to make them better prepared to the world of work. The outcome of the interdisciplinary engagement was to examine if a green building on campus set out to achieve triple bottom line sustainability outcomes. Undergraduate students from final year in construction management, and business and IT worked with Masters students from computer science to explore their own discipline related knowledge while being mindful of other discipline related students and their contributions to the overall project. The project was premised on engaging students in interdisciplinary thinking and practice. The focus of the project was an iconic green building on campus. It engaged students in understanding whether this green building was indeed achieving its claims.

This paper commences with a description of the project and its approach. The underlying conceptual frameworks are then described followed the results and discussions, and conclusions.

THE PROJECT AND APPROACH

The project has been guided by an interdisciplinary framework, and using a case study approach. The underlying framework in guiding the case study approach is the value of interdisciplinary engagement and the opportunity of using a university building for student learning as well as identifying where building improvements may be made. As the university is situated in an urban campus committed to the practice of incorporating sustainability principles and practices into learning and teaching, research and operational activities, an opportunity was presented in using the campus buildings for teaching and learning. These have been discussed further in the following sections of the paper.

This project was funded by a Victorian state department in Australia, interested in supporting student engagement in the real world. The grant was awarded through a competitive process and the entire project lasted the final academic semester. The project team consisted of investigators/teachers from the disciplines of construction management, computer science and business with attendant students also from these disciplines. The total number of students were seventeen: five in construction management, six each in business and computer science.

Key stakeholders, who were involved in the planning, design, construction and operation/use of the building, were invited to participate in the project. The role of the stakeholders was to guide the students in

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engaging with their projects and mentor them. In consultation with the building manager, 8 spaces were selected for study across the building. These were the main spaces that all the students focused on, however, each cohort of students focused on the problem within their own disciplinary boundary. Assessments were separate for each of the student cohorts and the course was not redesigned to meet specific learning outcomes.

Students were brought together formally three times during the semester for this project as a group. The first time was to introduce the industry stakeholders also acting as mentors for the students. This provided an opportunity to describe the overall aims of the project and respond to specific questions on the spaces selected for study. The second formal workshop was half way through the project, when the students presented initial findings for feedback from the stakeholders. The final presentation was at the end of the semester, when final assessments for the project was due. Beyond these formal meetings, students interacted with their own teachers in the different schools and sought advise as required in the development of their own projects and to meet their course learning outcomes. Students were encouraged to meet students from the other disciplinary cohorts as the semester progressed.

This paper reports the overall outcomes resulting from stakeholder engagement, student interactions, assessments, course and program learning outcomes and teacher participation. Construction management students used the building to focus on understanding thermal comfort in selected areas of the building, while the business students focused on the user needs and value of the selected spaces in the building through surveys. The computer science students used online surveys for creating an application focused on understanding the user interaction in the space and satisfaction. There were some overlaps between the three groups of students. Broader outcomes of the research were to assist the University to improve future building developments, along with creating a living case study for integration into student curriculum.

The underlying conceptual frameworks of this project are briefly described below.

INTERDISCIPLINARY ENGAGEMENT

The context for this study comes from the nature of the built environment discipline itself. The built environment disciplines focus on the application of applied knowledge. There is no single built environment discipline, by its very nature; the built environment comprises a range of disciplines. There has also been lack of a theoretical disciplinary base for the built environment (Chynoweth, 2009; Yocom et al 2012). Chynoweth argues that the built environment is in fact, not a discipline in the true sense and

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requires the built environment academic community to develop a common epistemological axiomatic to make it truly interdisciplinary.

The outcomes of interdisciplinary teaching and learning is linked with contextualised, applied and transdisciplinary knowledge whereas discipline based research is pure, discipline specific and often has a complex and rich history (Manathunga et al, 2006). Interdisciplinary teaching and learning can be applied at both undergraduate and postgraduate programmes and there may be an argument to say that all post graduate programmes should be interdisciplinary if they are to have any real world applications.

Accompanied with interdisciplinary are other related terms: transdisciplinary, multidisciplinary, pluridisciplinary and crossdisciplinary. While debates still exist about interpretations, there are some common understandings across the literature (Chynoweth, 2009; Manathunga et al 2006, and built on the works of Grigg (1999, 2003) and Jantsch, 1972). Transdisciplinary engagement establishes a common system of concepts and understanding for a set of disciplines. In multidisciplinary engagement, several disciplines may be used simultaneously and possible relations between them may not be made explicit. It is characterized by an additive approach, rather than synthesis between the disciplines. In pluridisciplinary engagement, there is a deliberate juxtaposition of different disciplines to enhance relationships. In crossdisciplinary engagement, in addition to the juxtaposition is the deliberate attempt to coordinate the relationship between the different disciplines. It is quite possible that one discipline may deliberately impose its own disciplinary concepts and axiomatic. The relationships between the disciplines are not characterized by collaboration, dialogue and relationships, but more about control.

Academic engagement for supporting interdisciplinary teaching is critical. Callaghan (2015) used reflective collaboration to support various disciplinary contexts in the engineering, built sciences and information science educational disciplines. The three-year process of reflective collaboration found that dialogue, critique and reflection supported transformation of challenges into learning opportunities for the teachers. Student outcomes resulting from interdisciplinary learning are: curiosity, respect, openness, patience, diligence, self-regulation, social experiences, and educational experiences.

One of the earliest examples of interdisciplinary education in Australia is the case study of Griffith University with over four decades of interdisciplinary teaching and learning (Franks et al 2007). Queensland University of Technology (QUT) also reported the use of an interdisciplinary collaborative and teaching project within the faculty of built environment and engineering focusing on sustainable development to facilitate creative teaching and learning (Shanableh et al 1998).

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Recognising that interdisciplinary engagement in the built environment disciplines is important has also been reported (Wood, 1999). Interviews with senior academics in his paper showed that academics favoured multidisciplinary project work to foster a more collaborative approach to interdisciplinary working. In another example of using studio education in the planning and design disciplines in the USA, the authors noted the importance of collective understanding and sharing disciplinary vocabulary to improve students' communicative techniques (Yocom et al 2012).

In this paper, interdisciplinary focuses on the additive learning outcomes gained not just through the course learning outcomes of the various Schools involved, but also an overall outcome of enhancing students' higher order thinking and cognitive skills. In other words, while the course learning outcomes were focused on Mode 1 (discipline specific), the engagement across different schools also sought to achieve Mode 2 (transdisciplinary aligned with real world outcomes) (Gibbons et al 1994, Manathunga et al 2006).

There are barriers to interdisciplinary teaching and research (Franks et al, 2007). The shift from discipline based knowledge to more integrated approaches is beyond the comfort zones of most academics. Communication is critical so there is shared understanding and relationships developed between the various discipline based academics. It is also difficult to publish interdisciplinary work. Innovation in education has mostly been linked to technology, but innovation can also be applied in teaching and learning in an interdisciplinary environment (Dima, 2013).

UNIVERSITY CAMPUSES AS LIVING LABORATORIES

Universities can be used as a living laboratory or lab to achieve triple bottom line outcomes for the university, whilst using campus assets as a part of student education. Living labs constitute a form of experimental governance, where stakeholders develop and test new technologies and ways of living to address the challenges of climate change and urban sustainability. Applied research undertaken in the real world offer a framework to not only connect students to applied research, it also offers the opportunity to bring a range of stakeholders together to work collectively to solve a common problem. In the process of coproduction novel and innovative approaches can be trialled in often non threatening environments leading to new sustainability technologies and services. One of the key considerations of coproduction implies collaborative efforts across sectors as well as between disciplines so that the resulting solutions are truly holistic in nature, essential to address sustainability challenges.

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Lack of coordinated approaches to engaging in interdisciplinary approaches have been highlighted by Filho et al (2015). Evans et al (2015) note the importance of engaging with non academic teaching staff, and Elliott and Wright (2013) discuss the importance of student engagement. Other authors such as Capdevila et al (2002) have shown that integrating research and education is essential for success. Muller-Christ et al (2014) report on the importance of the 3Cs: Campus, Curriculum and Community for putting sustainability into practice. Campuses may be used to engage all members in sustainability practice throughout the university, curriculum changes offer a window of opportunity to bring theory and practice within universities together and communities can be formed within the universities itself, creating role models of engagement.

Using the case study of business schools Painter-Morland et al (2016) discuss the importance of adding ‘systemic institutional integration’ to integrating sustainability in business education and management. These are ‘piggy backing’, digging deep’, ‘mainstreaming’ or ‘focusing’. Piggy backing refers to inclusion of sustainability integration to individual courses such as guest lecturing. Digging deep is about integrating sustainability through new stand alone modules which may be electives. Mainstreaming integrates sustainability within existing structures with emphasis on broader cross curricular perspectives for the entire program. Focusing is about the integration of sustainability through new crossdisciplinary offerings such as sustainability related courses and other new offerings. Systemic institutional integration comprises of leadership and capacity building across schools.

There are limitations as to why green buildings are not mainstream in university campuses (Richardson et al 2007). Empowerment of university leaders and staff to catalyse and implement new paradigms for sustainability have been noted as a key reason by these authors and others (Lozano et al 2013). While the literature is focused mostly on success stories rather than on failures, lack of transparency of failures impedes overall understanding of learning outcomes (Velazquez et al 2005). There is no one recipe or approach for the successful implementation of sustainability programs across the world. Yet, despite this as has been evidenced from this section; sustainability initiatives across university curricula and campuses are flourishing.

RESULTS AND DISCUSSIONS

As already indicated, the courses in each of the schools considered were not restructured. Course learning outcomes remained the same, however, all students examined spaces within the green building in their study to assess and understand overall, whether triple bottom line sustainability was achieved through their own disciplinary boundaries. Assessments

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remained within the course learning outcomes in the disciplinary boundaries. However, students engaged with others to understand whether the building was comfortable to work in and what were the key areas for improvement in the building.

External stakeholder engagement with the building manager, architect and specialist consultant was successful. They assisted the project team in determining the spaces to be studied. Enthusiasm by the internal stakeholders; facilities department of the university and program managers of the three schools was modest. The facilities department staff were only interested in issues requiring maintenance. The program managers of the three schools were not interested in the underlying interdisciplinary concept of why the project was spread across three schools. A very senior learning and teaching academic supported the project, remarking that the project lead had accomplished a great feat by 'involving staff, students and industry across three schools in three distinctive areas of the university'.

Teacher participation varied. Where the course coordinators were also the investigators involved in the project, coordination and support for the project itself resulted in better teamwork. Where the course coordinator was not the teacher involved in the project, shared ownership and goals were more difficult. In computer science, this project was part of a capstone supporting the innovative outcomes for this project. The course coordinator was also the investigator, resulting in better planning, leading to a higher quality of assessment, student engagement and interaction, and follow up with students. Involving senior staff such as the Dean/Head of School across the three schools would have assisted in securing the top down support, a critical factor that the literature has also noted.

Student interactions varied. The interaction between the students of the various disciplines were limited. Students within the same schools interacted more with each other. On probing this further, it was found that timetabling, assessment scheduling and such other practical matters prevented students from engaging with each other beyond the project itself. The overall observations made by the three cohort of students in the study of the building are presented below.

Learning spaces: Of all spaces studied in the building, student portals were the most liked places compared to the lecture theatre selected for the study. This is not surprising as the project building's occupation patterns by students surpassed university expectations. Students observed that this green building had a very different layout of rooms compared to other spaces on campus. Students found it easier to communicate with each other as a result of good design and room layout and felt that learning outcomes were realised, leading to less stress. However, room layouts were not necessarily conducive always to communication where eye contact could be maintained. There were

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situations where the room layout presented the person's back to the class. Placement of air vents under the chairs were also not the most effective way to dispense air circulation in the space, as few students felt quite cold at the end of the class. Use of the white board was not always successful due to technological difficulties.

Common spaces: Students complained of glare in common student spaces. Some students preferred a designated quiet study area. However, these did not work particularly well as the acoustic separation was still a problem in the quiet study spaces. Students indicated that there were not enough power outlets. Over ninety percent of students using the study area were observed to be using an electronic device and it was critical to provide more of these to facilitate student learning outcomes. Some spots in the building also had poor internet connectivity, which was a cause of frustration for students. Unsatisfactory air flow in the café spaces studied, student hub, and some student portals and common areas were also reported, making the space quite uncomfortable to be in for long periods of time.

Coordination of the student and staff mentors, including the industry stakeholders was a logistical nightmare. Students' timetables invariably clashed, as did that of the lecturers. Considering the stakeholders provided their time for free, their commitment to the project was very high as demonstrated with their engagement with students.

CONCLUSIONS

This paper has shown that it is possible to use a campus project to bring three separate disciplines of staff and students to achieve triple bottom line sustainability outcomes. While there were many areas in the building that were comfortable, there were still some areas that needed improvement, particularly from a student perspective.

Engaging with staff from the three disciplines early, including senior management support from the schools was critical to meet the outcomes of an interdisciplinary framework. However, the project was not truly interdisciplinary as intended; it was in fact, pluridisciplinary. An additive approach between the disciplines however, raised student cognitive understanding although not explored to its full potential. Students were exposed to the real world through the project itself and engaging with the stakeholders. They worked alongside each other and were exposed to other viewpoints. Unfortunately, this could not be gleaned objectively due to timing of the project. For all students across the three disciplines this project was part of their final research papers.

Discussions with students during the various sessions and informal discussions confirmed that the engagement with stakeholders and other students led to some interdisciplinary reflections and deliberations. True

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interdisciplinarity would only be achieved if the project had a common course for the three cohorts of students with common course learning outcomes. Disciplinary underpinnings were not taught or discussed and debated by students for true interdisciplinary engagement to be considered. If sustainability outcomes are the overall focus, a university needs to find a way to integrate both curriculum and research. This project has taken a step in this direction, however, further top down engagement is critical to use the overall campus as a living laboratory.

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EARLY CONTRACTOR INVOLVEMENT (ECI) IN EVENT PLANNING AND MANAGEMENT

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ABSTRACT

Large and mega-events employ traditional procurement approaches, adopting an adversarial stance with contractors/suppliers. These events are often beset with problems with the contractors/suppliers. This study investigates whether early contractor involvement (ECI) is being applied to the procurement processes within the event planning and management industry and to explore the potential benefits and challenges of the application of ECI within that industry. ECI attempts to exploit the contractor/supplier's specialist knowledge and expertise to the benefit the project planning and design process to provide mutual benefits and minimise the drawbacks associated with an adversarial contract. This paper argues that an event is a particular type of project and discusses the potential benefits of ECI to the event planning and management industry. A literature review approach was used to explore the construction and infrastructure industries and the event planning and management industry to determine whether ECI is being utilized to any meaningful degree. Overall the study findings indicate that by adopting ECI the event planning and management industry could expect similar benefits to those observed in the construction and infrastructure industries.

Keywords: ECI, collaboration, event management, project management.

INTRODUCTION

Is an event a project?

A project is defined by the project management institute as "…a temporary endeavor undertaken to create a unique product, service, or result … has a definite beginning and end" (PMI, 2013, p 3). The project management institute describes a typical project management lifecycle as having the five stages of: initiating, planning, execution, monitoring and control, and closing (PMI, 2013).

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Projects come in a large variety of activities from construction, information technology, medical, business change, and events to name a few. Events are a particular type of project that includes conferences, exhibitions, festivals, special events, civic events, sports events and the like. Event management is the application of project management processes to development and execution of the event. The event management industry describes an event's lifecycle in the Event Management Book of Knowledge (EMBOK) in a similar manner to the project management institute's description of a project and although their stages or phases are named differently they correspond to the project management model, this similarity is not surprising as one of the key references used in the development of the EMBOK was the 2000 edition of PMBOK (Silvers, 2009).

An event is a form of a project and like construction, infrastructure and ICT projects they are categorized by their size. Müller (2015b) notes that terms like mega or giga-events are a recent phenomenon whereas previously they were described as large events.

For instance, Olympic Games as one of the leading international sporting events can be defined as a mega event since millions of people from cross the world attend the games and copious stakeholders are involved in the event. Figure 1 demonstrates the complexity of the various stakeholders' involvement in a typical Olympic Games event held every 4 years.

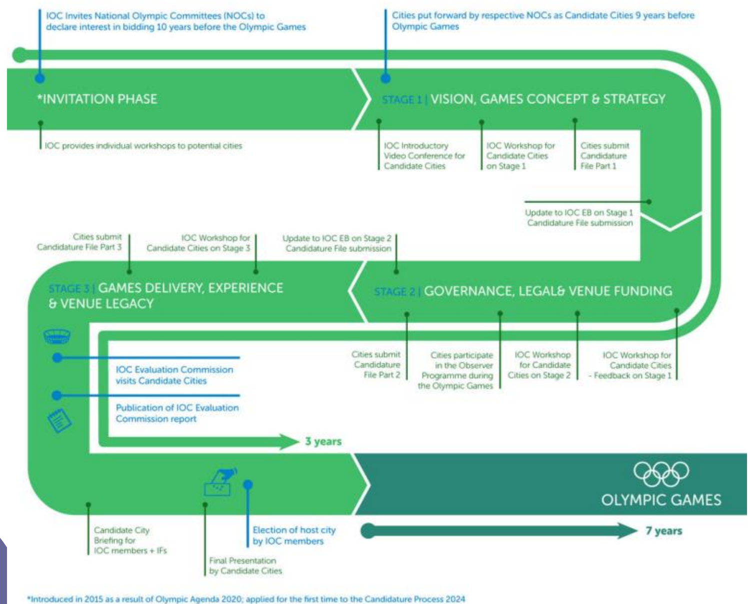

Figure 1 – involvement of stakeholders in Olympic games (Source: www.olympic.org)What is Collaboration?

Collaboration is a working practice in which individuals and organisations work together to achieve a common purpose. In the context of contracting, collaboration occurs when two or more participants work

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together to achieve a common business outcome while recognising that each party may have different business objectives.

Collaboration in the procurement efforts of a project can range from good ‘commonly used’ practices within the traditional procurement model through to specific collaborative procurement models. Collaboration is seen as a normal activity in achieving project outcomes by mature client and contractor/supplier organisations and can mitigate potential conflicts; facilitate knowledge; and help to integrate the parties’ specific capabilities to complete the project successfully (Rahmani et al., 2016).

The early contractor involvement (ECI) model of procurement is a collaborative contract approach to developing the tender for a project. Turner and Riding (2015) state that ECI broadly refers to the engagement that occurs between the project owner, designer and solution proponent (contractor/supplier) during the early stages of a project. The development of ECI was based on the premise that traditional methods create the team much too late in the project development and there is little scope for innovation and consideration of constructability (Edwards, 2009). Involving suppliers early in the project is seen to be an effective way of influencing project success (Aapaoja et al., 2013).

Defining ECI

Mosey (2009) describes ECI being developed by the Highways Authority in the United Kingdom (UK) during the early 1990s. The move to ECI was driven by the need to develop longer-term relationships with suppliers and create integrated project delivery teams (Whitehead, 2009). Since its initial use in the United Kingdom ECI has been adopted by government and public companies around the globe and is typically used in construction, defence, infrastructure, and transport infrastructure projects (Rahmani et al., 2013, Turner and Riding, 2015).

Within the literature, ECI does not have a single unified definition, it is defined in many different ways by different authors, the essence of the definitions is the same. For example: Nichols (2007) describes ECI as: “ECI is a form of partnering with the contractor appointed earlier than usual to help in planning, advise on ‘buildability’, and jointly develop a Target Price as the basis for a pain/gain share formula in the contract”.

It is argued that as the traditional procurement model excludes the main contractor/supplier and subcontractors from the early design and project planning it inhibits opportunities for innovative solutions, constructability, and health and safety planning into design (Edwards, 2009, Mosey, 2009). On the other hand, ECI integrates people, systems, business structures, and practices into a process that collaboratively harnesses the talents and insights of all parties to optimize project results, increase value to the owner, reduce waste, and maximize efficiency through all phases of the project.

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Exploring the benefits and challenges of ECI

The analysis of ECI construction and infrastructure projects by Whitehead (2009) identified many advantages over the traditional project delivery contracting models. This was supported by Rahman and Alhassan (2012a) who listed additional benefits of ECI.

In the United Kingdom, where ECI has been used since 2001, the generally held view is that there have not been any peculiar disadvantages identified with the model (Whitehead, 2009).

The analysis conducted by Rahman and Alhassan (2012a) identifies that involved parties' commitment and attitude to the performance of the ECI are two of the most important factors to achieve a successful outcome. All parties to an ECI must be willing and committed to building a lasting relationship (Mohr and Spekman, 1994) as the consequence of a party being unwilling to commit or the commitment being one-sided is that the trust relationship will be eroded (Kadefors, 2004). The parties will be unable to develop a win-win approach to the ECI if any of the parties is uncompromising in their attitude to the other the parties (Ng et al., 2002). A fear of change from the traditional ways, a lack of experience in working in ECIs, and past bad experiences from previous adversarial contracts can lead parties to be untrusting of one another (Glagola and Sheedy, 2002, Kadefors, 2004)

Common problems in event management

An investigation of academic and industry publications into the problems associated with the planning and management of large or mega events unsurprisingly resulted in a similar list of project problems as those typically listed in construction, infrastructure, and ICT (Flyvbjerg, 2005, Flyvbjerg, 2011, Giezen, 2012, Müller, 2015a, Solberg and Preuss, 2015).

Understudied areas and application of ECI

Since ECI has been originally formulated for infrastructure and large-scaled construction projects, the majority of studies essentially focus on the different aspects of ECI within the building and construction industry (c.f. Song et al., 2009, Wondimu et al., 2016, Rahman and Alhassan, 2012b). However, a number of researchers also recognised the potential benefits of early involvement of contractor/supplier in other industries and conducted a few studies in different areas. For example, Wynstra et al. (2000) adopted the concept of ECI and developed the driving and enabling factors for purchasing involvement in product development within the business and marketing industry. Gil (2001) also utilised the principles of ECI in lean product-process development process to support contractor involvement during design.

Nevertheless, Turner and Riding (2015) observed in their review of key early contractor themes that an understudied area of ECI is the other

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involved parties such as: project managers, operations, maintenance, engineering, and asset management services. Another understudied area is the application of ECI in other industry segments such as event planning and management which is the focus of this study.

RESEARCH AIM AND METHOD

This study sought to identify whether ECI is being applied to the procurement processes within the event planning and management industry and aimed to explore the potential benefits and challenges of the application of ECI within the event planning and management industry. This study was qualitative in nature taking an interpretivist philosophical position and employing a literature review approach.

The study gathered secondary data that was obtained from relevant academic and industry literature. The searches resulted in many articles involving ECI's use in the construction industry but few results involving ECI being used in the event planning and management industry, as a result the construction industry material was used as a basis for interpreting ECI in the event planning and management industry.

The motivation for this study was to investigate whether ECI would be a suitable contract vehicle to help overcome some of the common problems that plague the planning and delivery of large events. The scarcity of both academic and industry research that has been carried out and reported in journals and other publications on the use of ECI within the event planning and management industry has placed a constraint on this research study

ANALYSIS AND DISCUSSION

Large and mega-events have a positive influence in local economies and tourist numbers (Teigland, 1999, Matheson, 2006) resulting in the ever increasing size and extravagance of these events and the continued expansion of the event planning and management industry.

Current event planning and management industry guidelines suggest that large and mega-event projects require at least a two-year planning timeframe. This results in large and mega-events having extended planning and implementation stages. Flyvbjerg et al. (2004) have demonstrated that large and mega projects are subject to delays and cost overruns due to their extended planning and implementation stages.

To accommodate the growth in the size and frequency of these events the guidelines governing event planning and management require revising. Locatelli and Mancini (2014, p 285) suggested "new tools and guidelines are required to deliver events". One of the emerging tools is ECI. The

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ECI approach to procurement contracts is gaining popularity in the construction and infrastructure industries but there is little evidence to suggests it is a commonly used practise within the event planning and management industry.

In the late 1990s the UK's Highway Authority developed ECI. Around the same period Bramwell (1997) was advocating that event managers needed to engage in participatory planning processes and emphasised the importance of strategic planning for large and mega-events. Participatory planning is a euphemism for collaborative planning which is the premise for ECI.

The World Student Games held in Sheffield (UK) in 1991 suffered from greatly reduced visitor numbers, cost overruns, and other problems. The games used a traditional procedural procurement process and as Bramwell (1997, p 174) noted "…the games were sometimes depicted as crisis ridden…". A participatory planning process may have averted many of the problems by involving the contractor/suppliers early in the planning of the games. According to Peter Lundhus quoted by Bundgaard et al. (2011) "Too little use is made early on of the knowledge of contractors".

Although many authors have expressed the benefits of engaging with suppliers earlier in the project lifecycle, the event planning and management lifecycle (Figure below) as defined by Event Management Book of Knowledge (EMBOK, 2016) suggests engaging with suppliers during the implementation phase of the event lifecycle, well after the event planning has taken place, therefore losing the opportunity to leverage the knowledge and expertise of the contractor/suppliers.

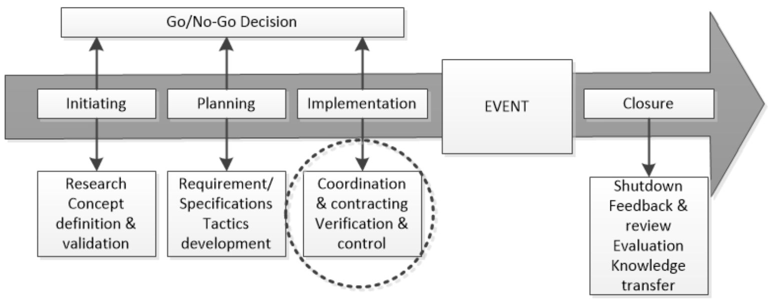

Figure 2 - Event planning and management lifecycle
(Source: EMBOK (2016))

At the moment, an "over-the-wall" practice prevails in the event planning and management industry where the event design is passed along the chain of parties until it is considered to be ready. This prevailing practice indicates an absence of a collaborative or participatory process to utilise the knowledge and experience of the contractors/suppliers during the planning stage. This prevailing practice leads to the overall event being sub-optimized as the individual stakeholders strive to optimize their own performance.

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While the benefits of collaboration have been widely acknowledged by the construction industry, a successful partnering should begin early, prior to contract award or the procurement selection process in order to deliver the best value to a project (Rahmani et al., 2013). One of the more frequently observed benefits of ECI arises from the joint or participatory problem solving processes that is introduced early into the project resulting in "state-of-the-art knowledge being available from the contractor early on" (Bundgaard et al., 2011, p 28). This creates a better awareness and understanding of the risk profiles associated with the project. The longer term commercial consequences of a project will be better understood earlier in the lifecycle enabling appropriate remedies to be found earlier. This approach places the project owner in a position to identify and manage risks more effectively (Rahman and Kumaraswamy, 2004, Mosey, 2009).

Aapaoja et al. (2013) and many other authors have observed that the early involvement of contractors/suppliers in the project leads more efficient and effective problem solving and decision making. Swainston (2006) demonstrated that the cost of making a change early in a project is comparative low when compared to making that change later in the project's lifecycle.

Nevertheless, there are some barriers in involving a contractor at the early stage of a project, including challenges in the areas of contracting practice, teamwork and culture change (Song et al., 2009). One of the challenges is the contractors' concern about adequate regulations to prevent other competitors running off with their ideas and the intellectual property issues of their contributions to the design. Choosing suitable project participants for an ECI, and ambiguity in defining the role of consultants and their relationship between client and contractor throughout an ECI contract also can be seen as the challenges in using an ECI (Bundgaard et al., 2011). Clients also find competition and trust as challenges they might face in adapting an ECI contracting model (Bundgaard et al., 2011). Scheepbouwer and Humphries (2011) examine ECI against the transitional projects issues and assert that disagreement over risk allocation, time constraints and cost reimbursement as well as level of staff capability and input, are issues in implementing ECI project delivery for all committed parties that should be adequately addressed.

CONCLUDING REMARKS

This study was based on an exploration of existing literature. The event planning and management industry appear to be locked into the traditional procurement cycle and scant evidence was uncovered in the academic and industry literature to demonstrate that ECI is being applied in any meaningful way. The exploration of the literature has demonstrated that the problems experienced in large and mega-event

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projects are essentially the same problems that were experienced in the construction and infrastructure project prior to the adoption of ECI.

Many authors have written on the benefits and drawbacks of ECI in the construction and infrastructure industries. ECI is essentially a simple change to the "when" the contractor/suppliers are engaged in the procurement activities of a project so that their knowledge and expertise can be leveraged.

This change to the "when" the contractors/suppliers are engaged can be applied to all projects regardless of the industry domain. ECI could be applied to the event planning and management industry and the industry could expect to receive many of the same benefits that have been observed in the construction and infrastructure industries.

While the findings of this study are limited, they provide a basis from which further research can occur in understanding the benefits and drawbacks of ECI in the event planning and management industry. Further research to gather primary data will allow for a deeper analysis of the interaction of ECI in the management of large and mega-events and the opportunity to compare the outcomes with construction and infrastructure projects.

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AN ETHNOGRAPHIC INVESTIGATION INTO A SERIES OF INCIDENTS ON A LARGE CONSTRUCTION PROJECT

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ABSTRACT

A series of incidents in a short period created cause for concern on a large construction project in the UK (+£500m). Incident investigations are one of the ways to learn about safety failings, so that remedial action can be put into place to avoid a recurrence. The researcher was a member of the H&S department, with the role of a participant observer during the incident investigation period. Data collection included: informal conversations with employees; attending safety and accident investigation meetings; viewing project documents; and attending the safety stand down that occurred. The case study findings revealed that a blame culture restricted information flow on the incidents; and consequently there was a focus on easily observable unsafe acts, and static unsafe conditions, providing a narrow rather than deep perspective. These acts and conditions, such as a lack of compliance with PPE, or a weather condition, were often difficult to manage. For safety understanding the project repeatedly used Heinrich's (1931) seminal work as a foundation. However, this work is arguably outdated as it focuses on accidents on an individual rather than complex socio-technical level.

Keywords: construction, safety, accident investigations, ethnography

INTRODUCTION

Learning from previous accidents and incidents is important for preventing future injuries and losses. Hence even the most trivial incidents and near misses should be fully investigated, as there are potential learning opportunities without having to endure the consequences of an accident. During a ten-day period there were eight incidents on a large construction project in the UK (+£500m). The researcher spent time as a member of the H&S department during this period, and explored the investigation process for these accidents. The main aim of the research was to understand the greatest challenge to undertaking effective incident investigations.

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INCIDENT INVESTIGATIONS

In early safety work, Heinrich's (1931) focused on safety at the individual worker level, highlighting that 88% of accidents were caused by man failings. However, it has since been argued that this view on the cause of accidents is not compatible with the modern perspective; and that current thinking about how accidents occur and their casual factors has moved away from individual worker behaviour, with emphasise being placed on improving the work system (Manuele, 2011). Depending on an organisation's perspective, the accident investigation could reveal very different causes; and investigations that do not relate to the actual causal factors, will inevitably have corrective actions that are misdirected and ineffective (ibid).

An event investigation is the collection and examination of facts related to an occurred specific event (Harms-Ringdahl, 2004). Incidents are events that could have or have resulted in harm, such as a near miss, minor or major accident. As such, incident investigations incorporate events that could be accidents, often referred to as a 'near miss' or 'close call', as well as accidents. An accident investigation is one of the elements in the process of learning from accidents (Cedergren, 2013). Fully investigating accidents and incidents can reveal information that can be instrumental in avoiding the recurrence of subsequent failures (Johnson & Holloway, 2003). For safety improvements it is essential that the recommendations on remedial actions presented in these investigations are implemented (Cedergren, 2013). Kletz (2002) highlighted that missed opportunities following an accident investigation include:

- Only finding one cause, usually the final trigger before the accident
- A focus on immediate causes but not ways of avoiding weaknesses in management
- Using the broad term human error without being more specific
- A focus on causes that little can be done about
- An emphasis on procedural change rather than design
- Experience learnt is not shared with others
- Lessons learned are forgotten and the accident reoccurs

Kletz (2006) also highlighted that the report deriving from the investigation should not be viewed as 'closing out' a problem, but instead ask 'what else could be done'? Near misses, minor accidents and some major accidents have investigations that are typically undertaken by the construction organisations where the incidents occurred. Severe accidents are sometimes investigated by government bodies, such as the HSE (Health & Safety Executive) in the UK, which satisfies both: the public need for answers to what happened; and their need for reassurance that

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action will be taken to address the failings that led to the accident (Boraiko et al., 2008). The seriousness of a major accident and the potential legal implications can result in a more narrow and closed investigation, as opposed to near misses and minor accidents, which can be more open during the investigation process.

RESEARCH METHODS

Ethnography is a method of observing specific group in their natural setting (Phelps and Horman, 2010). Proponents of the use of ethnographic approaches in safety research have claimed that it can: offer rich and practical understanding concerning the complexity of informality in safety learning processes (Baarts, 2009); and enable a more sophisticated and nuanced assessment of safety culture than possible through other assessment techniques (Strauch, 2015). Pink et al. (2010) also argued that ethnographic approaches can go beyond what could be said in an interview; and Oswald et al. (2014a) explained that by establishing rapport with participants, the researcher can get access to data that may not normally be available, such as insights gathered from an accident investigation.

Ethnographic research is it often very time-consuming in comparison to other methods; and with regard to accident investigations, Strauch (2015) pointed out that ethnographic methods require more time to conduct a study than is reasonably available to incident investigators. Research adopting ethnographic approaches to explore accident investigations are rare, though there have been a few studies. For instance, Sanne (2008) found that in an incident-reporting scheme, employees must be given ownership, must know how and why to use it, and that there is a need feedback on root causes; while Oswald et al. (2015) revealed that an accident investigation found a combination of: time pressure; the shortage of skilled-labour; untrained workers; and poor planning all contributed to a minor accident.

As part of a wider three year ethnographic study, the researcher visited the construction project between one and three times a week for three years, adopting the role as a participant observer, who had no control over events or investigation processes. This case study focuses on the ten day period where eight incidents occurred on a large construction project (+£500m) in the UK. On this project participant observation included a mixture of: attending accident investigation meetings, H&S meetings, site offices, canteens, work sites, the safety stand down, viewing project documents, and having informal discussion with employees throughout the hierarchy from directors to labourers. The data collection and analysis

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were a concurrent process (Silverman, 2013), and was collected and analysed until a point of saturation was reached (Kumar, 2005).

DISCUSSION OF FINDINGS

H&S manager: '*I don't know what the hell is going on. Another incident today. Get out there, get talking to people, let's find out what is going on'*

On the return from the Christmas break period, a series of incidents were a cause for concern on a large construction project. Investigations were carried out, but gathering all the relevant information was challenging. One of the accidents occurred when a welder dropped his chip hammer on the level below; and when he went to retrieve his hammer, he then fell through a partially unprotected temporary opening, suffering minor injuries. In the investigation, the H&S team had doubts about whether they were receiving all the information. One H&S advisor stated:

'*Call me a sceptic but I went down there, and you can see the outline from the dust and cuttings of where the baton [wooden plank] was. His [injured persons] story of what happened doesn't add up with the evidence. He's not thrown himself down there, but there is something not right. I don't think we have all the details, and we probably never will.'*

When incidents occurred, the H&S team were frustrated they were often not able to gather all the relevant information. H&S professionals would frequently make remarks such as:

'*we are being fed bullshit. Information is being sanitised at every level*.'

With incidents that could lead to disciplinary action, information was particularly restricted; and where gross misconduct occurred it was recognised that individuals should be held accountable. However where acts, such as mistakes or errors occur, there should a perception that reporting can follow without fear of blame (Johnson & Holloway, 2003; Reason, 2008). At least in the UK, it is more legally convenient to blame individuals (Reason, 2008); and investigating employee-based causes can be attractive to internal investigators, as they may be put in a difficult position if an underlying cause of an incident is an organisation's policy or culture (Kletz, 2006). However such a blame culture can create an environment that is very difficult to learn from (Reason, 2008).

The lack of information meant that the causes of the incidents were often attributed to unsafe conditions, rather than unsafe acts. Smith et al. (2017) noted that it is more difficult to observe fluid and momentary unsafe acts when compared to static and unchanging unsafe conditions. The acts that were documented were typically 'easy to observe' acts (see Fleming and Lardner, 2002), such as not wearing the correct PPE

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(personal protective equipment). This unsafe act is typically observable for a longer period than other fluid and momentary unsafe acts. Hence there tended to be a focus on easily observable unsafe acts (such as lack of PPE) and static unsafe conditions as causes. For instance, one minor first aid accident occurred when a delivery driver was not wearing gloves and cut his hand. The lessons learned document stated:

'*Enforce offloading procedure, incorrect PPE for the task'*

H&S advisors were continually frustrated with the breaking of site rules such as non-compliance with PPE. Walker (2010) explained that the workers had developed a 'counterculture' to the official safety pronouncements of management. One of the greatest challenges the H&S department faced was compliance with tool-tethers to avoid dropped tools, as this posed a high-risk. Incidents where tools were dropped raised the following documented lessons learned:

'*Tool lanyards should be used where risk exists. Exclusion area below to be enforced.'*

However even when risks did exist and tethers should have be worn, this site rule was not always adhered to. Workers explained that sometimes the tethers available were impractical, depending on the motion of the tool (e.g. twisting), while other workers simply did not want their own tools permanently tethered. One operative stated:

'*We are the guys having to use the tethers, but we weren't consulted. They just buy a bunch and expect us to use them, when they might not work for all us. We have scaffs, joiners, welders, all doing different work.'*

The workers did not believe the tethers were practical for all trades and scenarios, but superiors argued it was a site rule, and therefore must be adhered to. Paap (2003) proposed that in the construction industry safety should be interpreted in two forms: the official procedures and the actual working operations - a distinction that represents the difference between the rules stated and the rules that actually govern the workplace. This double-provision was described by Paap (2003:221) as 'a Bait-and-switch, since it clearly serves to advantage the employers at the expense of the workers'. This was a contentious issue as workers desired more 'common sense' with rules.

While there were often issues surrounding the PPE compliance as an unsafe act; unsafe conditions were more frequently highlighted as incident causes. For instance, a trip and fall resulting in a minor injury led to a corrective action documented as:

'*Control of access to incomplete walkways, correct protection and marking of openings'*

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Most of the unsafe conditions the contractors had control over, but there were some they had little over. One of these conditions was the wind, which is an accident investigation finding that Kletz (2002) would classify as a missed opportunity, as very little can be done about it. A minor first aid accident that occurred on site was logged as:

'*Dust/grit blown in eye, eye rinsed out'*

The lessons learned from this event were detailed:

'*High Winds- continuous reassessment of tasks/prevailing weather conditions*'.

Rozenfeld et al. (2010) highlighted that exposure to weather conditions is one of the many unique characteristics of the construction industry. The weather is not just a condition that can be unsafe, but it also disrupts the work. As work falls behind schedule production pressures can increase; which has been linked to poorer safety performance (Oswald et al., 2013; Han et al., 2014). Following an incident where an operative tripped, fell over and required first aid, an H&S stated:

'*We are 8 days behind already because of the weather. Guys are getting frustrated that they are behind, and are taking risks by not concentrating or paying attention'*

Previous work has suggested there is a particularly the high risk tolerance found on construction sites (e.g. Rawlinson and Farrell, 2009). Oswald et al. (2014b) pointed out that as risks in the construction industry are mostly voluntary, under personal control, non-dread and known, and therefore they are more likely to be accepted and under-rated. The H&S advisors believed that production pressures caused by weather disruptions were initiating risk-taking, as workers were focusing on job completion, rather than taking the time to finish the task safely. The Project Director reinforced this during the safety stand down:

'*There is no doubt we are under significant production pressure, but nothing is more important than safety. Take care when you are out there. I know some of you don't go out there often, but keep aware. Any of us can trip, fall or injure ourselves… it seems trivial… but it happens*.'

Slips, trips and falls are common accidents that are often have minor rather than major severity. It is arguable that some of these slip, trip and fall accidents are unavoidable or inevitable. However, the project management team believed the frequency of them was in part due to the production pressure and risk-taking behaviour. The concerning accident trend initiated a safety stand down to raise awareness, but this was not as successful as hoped:

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Commercial Director: '*It is amazingly to think of all the things we do with safety, systems we have in place, number of safety professionals, safety training, PPE and even initiatives like the stand down… and still… and still… it didn't seem to help because the day after the stand down finished we had another incident.*'

The H&S team reflected on the safety stand down and concluded that there were a wide range of differences in presentation quality. Those that were poorly communicated frustrated the H&S professionals:

H&S advisor: '*there were poor presentations; presentations with no open questions at the end to involve the guys [workers], and one had work going on next door so you could hardly hear. These presentations should come from the managers to show their commitment, but some aren't delivering it the way it should be*.'

Within the safety stand down document distributed the incident rate was described as:

'*a worrying trend which directly relates to the accident triangle which we are all accustomed to seeing. In reality the numbers within these accident triangles ARE PEOPLE!*'

In early safety research, Heinrich (1931) proposed that there was relationship between near misses, minor incidents, and major accidents; but its use has been criticised in the modern era (Manuele, 2011). At the time, Heinrich's work was ground-breaking, but its appropriateness within modern complex socio-technical systems has been brought into question. The accident triangle focuses on individual unsafe acts and personal injury accidents. Reason (2008) explains that this is an intuitively appealing approach which is frequently, but also inappropriately applied to organisational accidents. This is partly because accidents usually occur from multiple and interacting causal factors that often have organizational, cultural, technical or operational systems origins. Despite this, the large construction project repeatedly referred to Heinrich's work for guidance, such as in the safety stand down document. One H&S advisor explained:

'*We are still using research from the 1930s. There must be more recent work. There is a gap there because the research knowledge is not getting transferred. When I look at the recent research, it's so complex, all these models, what does it even mean?*'

The practitioners acknowledged they struggled to understand some of the more recent safety research, such as the socio-technical accident models developed. While important research developments have encompassed the complexity of accidents, to have practical use in the industry, such

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models need to be understood in the field. In comparison, Heinrich's accident triangle is easily understood, and therefore frequently used, despite being arguably out-dated.

CONCLUSIONS

Incident investigations have the potential to reveal important safety information to avoid future accidents. It was found that the greatest challenge to having an effective incident investigation was successfully gathering all the information on the incident. Important information was often not disclosed by workers, due to fears of blame. The restricted information meant there was a focus on easily observable unsafe acts, and static unsafe conditions, which provided a narrow, rather than deep perspective. Through this perspective, recurrent incidents were difficult to solve, as they often involved conditions that were hard to control (e.g. weather) or unsafe acts that were frequently undertaken and challenging to change (e.g. a lack of PPE). The safety stand down undertaken to raise awareness was ineffective due to varying levels of presentation quality across the site. It is recommended that there is a considerable effort to create a no-blame culture within organisations.

Heinrich's (1931) work focused on safety at the individual worker level, yet this is not aligned with current thinking, with emphasise being placed on the work system. In this case study, practitioners frequently referred to Heinrich's work for safety understanding, which suggests there may be a gap between modern safety research and the practical needs of the industry. The case study has raised the question of how modern research work can encompass the complexity of accidents, but also be understandable for practitioners, to have greater impact in the construction industry.

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PREPARING STUDENTS FOR A DISRUPTIVE CONSTRUCTION FUTURE

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ABSTRACT

Many industries have felt the impact of disruptive change on their profitability and established practices. Examples of disruption have been documented in industries as diverse as transportation, photography, newspapers, retailing, recorded music and computer graphics. The construction industry has mostly avoided large-scale disruption because, in spite of the globalisation evident in mega projects, most construction is locally-based and delivered within a specific national context and regulatory system. This may be about to change. The forces of digitisation, industrialisation and globalisation are combining to generate the potential for disruptive enterprises which will grab market share and shake up existing business models. As academics striving to prepare students to be employment-ready, we need to open their eyes to the potential of the new economy to support new business models that are quite different from traditional construction companies. Students will need to be entrepreneurial in seeking out opportunities and identifying market niches. In two new and developing units/subjects at an Australian university these issues are being raised. Students are challenged to identify markets and market strategies enabled by social enterprises, collaborative systems, the 'Internet of Things' and even 'Brutal Innovation'. Using student feedback and reflective practice, the lessons from the first two offerings of the new units are identified and teased out. In general, students respond well to the challenge of strategic thinking which relates to their future careers. While predicting the future is always fraught with difficulty, not attempting to do so could leave us vulnerable to disruptive change.

Keywords: Construction futures, Digitisation, Disruption, Globalisation, Industrialisation.

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INTRODUCTION

Many students studying construction management today are true natives of this century. They have no memory of the twentieth century and are often very much transitioning to what is now called the 4th industrial revolution (Schlick 2012). As explained by Bloem et al (2014), the First Industrial Revolution commenced with the harnessing of water and steam power at the end of the 18th century. The second stage was the introduction of mass production and the conveyor belt at the beginning of the twentieth century. The third phase is the digital automation of production utilising IT from the 1970s onwards. The fourth Industrial revolution is said to be happening now. This is predicted to involve increasing collaboration between humans and machines to the point of fusing the physical, digital and biological realms (Dombrowski and Wagner 2014). The world where the next generation of construction leaders will play out their future careers may be strongly influenced by digital complexity, globalisation, product industrialisation and market volatility. It will almost certainly be significantly different from that of past generations. Given the potential for significant disruption in the industry, it is important that educators foster discussion into the paths that the industry may take in the future. Many of our digitally literate students are already looking at the potential opportunities opening up for flexible, creative and innovative people to build themselves new enterprises and new ways of operating a construction business. We may already have some global game-changers amongst us. As educators, it is important that we are flexible in our response to external forces promoting change. New structures, content and assessments will be needed to make sense of the changes as they occur. The aim of this paper is to report on attempts to introduce the concepts of rapid and disruptive industry change to current students, so that they can seek out new opportunities in their future careers. They may even need to cope with an eras of brutal innovation where change processes wipe out past practices completely.

LITERATURE REVIEW

Digitisation

The introduction of computer technology in its many forms to the construction industry can be described as the process of digitisation. The gradual penetration of the digital world into the processes of construction has been studied by several authors. Shibeika and Harty (2015) found that the digital infrastructure to deliver innovation is incomplete and tends to result in tension between standardisation and customisation. Organisational change within a firm was found to strongly effect the diffusion of digital technology. Similarly, Osterreich and Teuteberg (2016) found that the uptake of digital technologies known as Industry 4.0 is patchy in the construction industry in the UK. However, they did find best practice examples that could demonstrate the benefits of digitisation to slow adopters. On the positive side, Ingram (2016) reported that construction businesses are being transformed by social media, mobile computing, cloud computing, data analytics and the Internet of Things (IoT). These drivers of change increase the pressure to perform for

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construction companies, but they also provide opportunities to create new kinds of construction enterprise. Case studies such as Merschbrock and Munkvold (2015) demonstrate the effective deployment of digital tools in a complex hospital building project. Ding et al (2014) found that the use of BIM technology enables dynamic and virtual analysis of scheduling, costing, stability, sustainability, maintenance, evacuation simulation and safety. While this possibility is there, it is yet to reach through to many construction operations. There is, however, some evidence that the digitisation of construction processes can improve the value delivery to clients (Sanchez et al 2016). Despite distinct unevenness in the uptake of digital technology in construction projects, it is now clear that the potential efficiencies are very significant. Students seeking to build a career in construction management in the coming decades will need to be tech-savvy and willing to adopt new methodologies and means of operating if they are to remain competitive.

Industrialisation

Off-site manufacturing of elements of building fabric and contents can be described as industrialisation of the industry. The growing trend towards this industrialisation has been observed by many authors with varying conclusions and recommendations. Jonsson and Rudberg (2014) developed a classification system to describe the degree to which industrialisation has been adopted on different construction projects. They found a classic dichotomy between the productivity benefits of industrialisation and the flexibility of outcomes available to customers. Ramaji and Memari (2016) studied modular construction models and found that information management systems already deployed in manufacturing were unsuitable for project-based modular construction incorporating modular factory-produced components. The authors propose a new Product Architecture Model (PAM) to incorporate the benefits of modular building into BIM and enable accurate life cycle assessment of multi-storey modular buildings. Santiago et al (2013) designed a factory layout that was dimensioned to suit a standard shipping container. They found significant cost and time benefits in comparison to onsite construction. The cost barriers to offsite construction were specifically examined by Pan and Sidwell (2011). The authors found that the increasing trend to offsite construction needed to be supported with long-term commitment so that individual constructors could gain experience with the delivery of such projects. Once a learning curve was established, cost benefits were seen to flow, but this did not happen automatically. Wong et al (2017) examined the readiness of some Australian construction companies to embrace prefabrication. While signalling some potential issues, they noted that many constructors saw the wisdom of the move to greater prefabrication and the benefits that can be claimed if organisational changes are made.

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The various forms of prefabricated, modular, panelised and volumetric construction as well as the 'componentisation' of building elements such as bathroom pods have become increasingly common in recent years. Significant investment in these areas is happening in several parts of the world. Consequently, it is important that construction students are aware of the move to reducing the onsite effort in construction projects and replacing this without offsite effort. This will impact the nature and extent of employment in the future construction industry. Students who are alert to the possibilities of these changes are more likely to be able to identify future opportunities.

Globalisation

The third significant trend identified from the literature on construction industry futures is globalisation. Globalisation has been described as "the inexorable integration of markets, nation-states and technologies to a degree never witnessed before in a way that is enabling individuals, corporations and nation states to reach around the world faster, deeper and cheaper than ever before" (Friedman 1999). Recent times have seen some political setbacks for this "inexorable" process which may not be as inevitable as the author perceived it. It is nevertheless true, that globalising forces persist in mercantile economies and are likely to continue to do so. While the construction industry has been largely insulated from the globalisation forces that have changed many other industries, this is not likely to remain the case in the future. Ngowi et al (2006) described the globalisation of infrastructure developments and their financing. The impact of this trend has already driven procurement and participation changes in many parts of the developing world (Badu et al 2012). The construction of 'mega-projects' has seen a dramatic rise in multi-national construction effort in many parts of the world. Mok et al (2015) undertook a systematic review of construction mega projects and found that such projects require a careful stakeholder management process if they are to succeed in a globalised world. Bi-lateral and multi-lateral Free Trade Agreements accelerate this process. Quality control in a globalised construction market has been demonstrated to be problematic in a number of recent cases of sub-standard building material substitutions, notably in the Docklands Lacrosse Tower fire in Melbourne in 2015. There are potential new careers being developed in the international assurance and certifying of new global procurement systems.

Disruption

The convergence of the three previously identified trends in the construction industry has the potential to create disruption in the manner experienced by many other industries. Since the early 1990s when he completed his PhD, Clayton Christensen has written extensively about the concept of 'market disruption' as a pathway for innovation delivery (Christensen 1992; Christensen 2006; Christensen et al. 2000;

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Christensen & Tedlow 2000; Christensen et al. 2002). He defined a disruptive innovation as one that creates a new market and value network and thereby disrupts and displaces an established market including its leading firms and alliances. Disruption has been documented in industries as diverse as health care (Christensen et al 2000), transportation (Cho and Parsons 2015), photography (Čiutienė and Thattakath 2014), newspapers (Karimi and Walter 2015), retailing (Christensen and Tedlow 2000), recorded music (Moreau 2013) and computer graphics (Pimentel 2015). Potential disruptive innovations identified by Jang (2013) include wearable computers, 3D printing, context awareness technology, driverless cars, ultra-light materials, gene therapy, and post batteries. At least some of these may impact on the construction industry. Rather than being overtaken by these changes, construction students need to identify the opportunities and make themselves part of the change delivery process rather than its potential victims. The identification of 'game-changing' trends in the construction industry will enable the students of today to start looking for these opportunities for a future rapidly moving global context. The process is presented graphically in Figure 1 below.

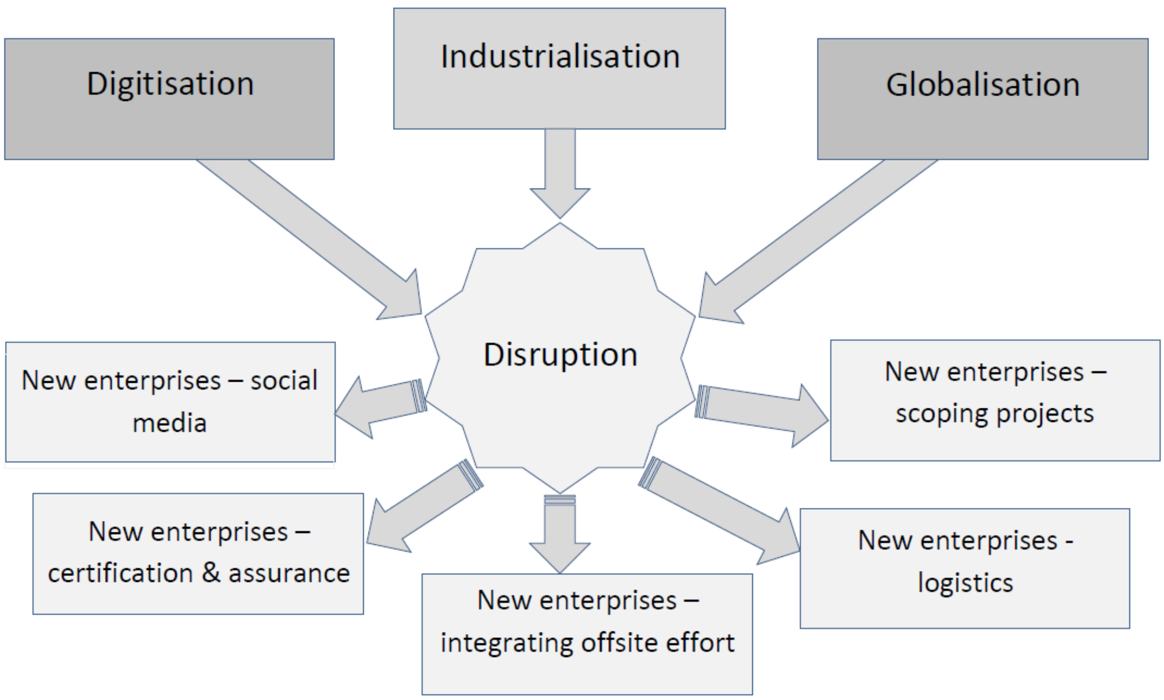

Figure 1 Potential disruption process

The new enterprise examples presented in Figure 1 arose as a result of discussion between the students and staff members as described below.

METHODOLOGY

For an educator reflective practice is about examining one's actions so that one can engage in a process of continuous learning. Paying critical

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attention to the events and values presented in the course of teaching delivery, while being aware of the educational theories which underpin that delivery, is a useful methodological practice. It is qualitative in nature and its rigour as a research methodology is dependent on continuous and systematic monitoring of the impact of the teaching delivery. Student engagement is one measure of effectiveness. Formal and informal student feedback must be collected and should be addressed without prejudice with regard to whether or not it confirms the educational intention. The literature of teacher education is replete with discussions of reflective practice but so is the literature of professional development (Biggs 2001; Bolton 2010; Ryan 2013). The concept of work readiness as defined by Cabellero and Walker (2010) is also relevant to this discussion, but this research examines the future of work in the industry and speculates that it may be very different from the past.

Table 1 Learning outcomes for Modern Construction Enterprises

	On successful completion of this unit, students should be able to:
1	Analyse the opportunities presented by the changing global environment in construction
2	Compare and contrast the trajectories of attempts at innovation in the construction industry
3	Predict major trends in construction modernisation
4	Hypothesise on the factors that contribute to successful modern construction enterprises
5	Make an original case for the adoption of changes to the way construction businesses are structured
6	Re-imagine construction enterprise models for the Indo-Pacific region

Table 2 Learning outcomes for Modern Construction Projects

	On successful completion of this unit, students should be able to:
1	Analyse the available indices that are used to measure construction productivity
2	Construct a case for improving project efficiency by means of industrialising construction projects
3	Examine ways to address quality assurance in a globalised construction market
4	Review the impact of the need for buildings to be adaptable over their useful lifetime
5	Theorise about the way to ensure that end users receive economic, environmental and social value from their buildings

This paper reports on the first delivery of two newly developed units in the recent 2017 Summer and Spring semesters at an Australian university. The units are called Modern Construction Enterprises and Modern Construction Projects. They are currently offered as electives to later year Bachelor of Construction Management students. The enrolment in the units was 25 and 35 respectively. This was particularly pleasing as no advertising or promotion of the new units to students was done at this time. However, it must be acknowledged that this leads to a bias towards the more engaged and active students undertaking the units. The units are differentiated by their emphasis on adaptation of the whole business

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in the first instance versus emphasis on procurement and project delivery in the second case. This differentiation was essential for the three stage unit approval system at the university which requires academics to be able to explain the learning intent to academics from other disciplines. The approved Learning Outcomes for the units are shown in Tables 1 and 2 above. As part of the reflective practice, both the academic and the industry advisor attended all the face to face sessions in the first delivery of the units. They took turns teaching and taking notes on the process. These peer observation notes will be used to develop and inform future offerings of the units. Of course, the success or otherwise of the units is judged by how well the students manage to meet the prescribed learning outcomes. This will become more apparent when they have been offered multiple times.

RESULTS AND DISCUSSION

This paper reports on a work in progress. The new units have only been delivered once at the time of writing. A great deal of preparation was done to ensure that the material presented was up to date and relevant to the Australian industry context. Guidance was given in these matters from the co-deliverer of the units who is an experienced industry practitioner with an interest in fostering a new approach to organising and measuring productivity in the construction industry. For the Summer unit, only two students failed and this was due to their not submitting all the assessments. On contacting both students, it was revealed that ‘pressure of work’ was nominated as the reason for failure to complete the unit. The marking spread was skewed towards the high grades (3 High Distinctions, 6 Distinctions, 9 Credits, 5 Passes and 2 Fail Non Submits). It was not possible to use the official Student Feedback on Unit data for this unit because the numbers responding to the survey were too small. Despite their reluctance to go through the official channel, students did provide informal feedback through other means. Two students posted on LinkedIn™ demonstrating their unprompted enthusiasm for the just completed unit:

> “Just completed my last lecture of the new "Modern Construction Enterprises" unit offered by xxxx University. A great unit with stimulating insights that left me excited about the future of the Construction Industry. Well done xxxx….” Student MS
>
> “I would love to the take the time to appreciate one of my universities senior lecturers who has dedicated her time and effort into establishing and developing a new unit called 'Modern Construction Enterprises' in which has allowed myself to explore and develop a greater understanding of the construction industry today and how innovative technologies are changing the way we build but also realising the downfalls that aren't quite working in the industry. I

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wanted to thank you for giving up your time to fulfil our minds as a student, hoping to take what I've learnt and to establish a career." Student BK

While these testimonials are pleasing and they received many likes from past students, they were reinforced by several informal comments and by the quality of the work that the students were able to deliver. The most important general criticism was that students wanted to see how the issues of sustainability and livability of construction output could be addressed alongside the change management described in the unit. This topic will be addressed in the next iteration of the unit. The peer observation feedback indicated a strong need to get students actively engaged in the material delivery. This will be the main target for the second offering. Development of new learning material is demanding of an academic's time and new units that look at the recent developments and future trends will need to be comprehensibly updated for each delivery. They cannot be static. Nevertheless, the first attempt was a positive experience and will be persisted with. Formal feedback on the second unit was not available at the time of writing. It will be available before the conference and could be included at that time.

CONCLUSION AND LIMITATIONS

It can be difficult to find the time to work on new course material in high demand study areas like construction management. The results of this experience were positive and invigorating albeit very preliminary in terms of verified research. Future offerings of the unit will be moving towards more active student participation in order to ensure that the units remain up to date and relevant. It is the author's hope and intention to continue with this work and report back on it in future AUBEA conferences in order to receive feedback from colleagues and to hear what reflective practices they are undertaking.

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INSTITUTIONAL ROLES IN EFFECTIVE STATUTORY ADJUDICATION IMPLEMENTATION

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ABSTRACT

Spearheaded by the Construction Industry Development Board and in conjunction with government support, adjudication and prompt payment regulations have been formulated to address unfair payment practices which have hampered the construction industry in South Africa. Given the complexity, contestability and disputatious nature of the environment in which construction activities are carried out, the implementation of policies is not an easy task. It requires strategies, deliberate plans and adequate institutional support. This paper investigates what measures are needed for effective institutional support and reports on the views of experts on what steps are required for implementation and the roles institutions play in ensuring an effective statutory adjudication process. Data were gathered through qualitative interviews with adjudication experts that have direct interaction and intimate knowledge of the adjudication process in the United Kingdom, Australia, Singapore and Malaysia. The findings identified five institutions that may enhance effective statutory adjudication implementation. However, only two of these five institutions are perceived to be critical and indispensable and without which effective implementation of the adjudication process will most likely not be achieved.

Keywords: Implementation, institutional roles, legislation, statutory adjudication.

INTRODUCTION

The concept of adjudication is no longer new in the South African (SA) construction space. Several pioneer works of the Construction Industry Development Board (CIDB) (CIDB, 2003; CIDB, 2005) and others like Maritz (2007) and Hattingh and Maritz (2013) have helped in drawing attention to adjudication as an efficient and appropriate means of

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Alternative Dispute Resolution (ADR) for the SA construction industry. Adjudication therefore appears to be gaining a lot more support in recent times, so much that all the four forms of contract currently endorsed by the CIDB already incorporate adjudication as an ADR process. At the global level the use of statutory-based adjudication has gained wide acceptance and has been widely researched and documented. As a result, many countries are shifting to adjudication as their principal mode of resolving construction disputes (Lim, 2005). The finding is that, where adjudication has been employed as the ADR mechanism, it has both timeously and adequately settled disputes and pacified the parties involved. In fact, adjudication at many instances has been reported to proffer satisfactory resolutions such that litigation was not necessarily required (Gaitskell, 2007; Gould and Linneman, 2008; Dancaster, 2008).

However, the SA construction industry players have as yet not benefitted from statutory adjudication and the level of its usage has been reported to remain low (Maritz, 2007). Apart from the fact that the practice of adjudication in SA is still based on contractual agreement, which is one the major reasons attributed for its underutilisation, institutional absence was also recognised as a challenge that can possibly impede its pragmatic functionality (Maiketso and Maritz, 2012). Therefore, rather than just keeping adjudication contractual, the SA construction industry mooted the idea of compulsory adjudication in order to overcome the problem associated with contractually-based adjudication practice. In light of this, draft regulations to support the practice of adjudication in SA have been prepared by the CIDB. Notwithstanding the provision of these regulations, the recent study of Maiketso and Maritz (2012) illustrates in clear terms that institutional absence must firstly be overcome for effective statutory adjudication uptake in SA. Accordingly this paper will investigate the relevant institutions needed for the effective uptake of the statutory adjudication, seek to discover the measures that are needed for effective institutional support, and report on experts' views on the roles institutions play in ensuring an effective statutory adjudication process.

LITERATURE REVIEW

Institutions perform important roles in policy implementation and they are integral to the functionality of any legislation (Salmen, 1992). This is because, without appropriate institutions, the enforceability of a particular legislation may be seriously undermined. For a policy to be effective there is a need for proper implementation strategies. When a policy is defectively implemented, it results in resistance and possible failure, which might lead to waste of resources and loss of potential benefits inherent in such legislation. Therefore, the complexity of construction processes coupled with the disputatious nature of the environment in which construction activities are carried out requires that adequate plans

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and effective strategies are put in place to achieve effective implementation of a new regulation.

Institutions vary and are diverse, and may include government institutions, education or academic institutions, legal institutions, professional institutions and voluntary organisations (TACSO, 2015). Literatures have provided strong support for the importance of institutions in predicting the level of development around the world and their significance in the realisation of policy objectives (Blase, 1986; Hall and Jones, 1999; Ferrini, 2012). The term "institutions" as used in this study mainly focuses on concrete institutions, i.e. well-established organisations (formal organisations, court of law, authorised nominating authority, government institutions as well as independent institutions responsible for the adjudication implementation) which fulfil certain purposes for the effective functioning of adjudication practices.

The proper functioning of any ADR mechanism depends on two aspects of regulatory frameworks – (i) legislative and (ii) institutional supports. There have been reports of poor implementation of policy and rifeness of non-compliance with regulations where institutional frameworks have been inadequate or non-existent to support such legislative framework (Ilter et al., 2007; Ilter and Dikbas, 2009). Therefore the successful deployment of new practices or policies depends on the planning and realisation of the related institutional framework as much as the adoption of legislation. However, this important infrastructure is often neglected (Ilter et al., 2007). It is herein noted and stressed too, that there are genuine and undisputable reasons to investigate the necessary institutional framework that can govern the policies and rules associated with adjudication, particularly in SA, where the implementation of the process is still relatively new.

In the construction industry there are many institutions whose activities influence the running and functioning of the industry. Some of these institutions are constituted by regulation or legislation. Some other institutions are formed to represent the interests of individual practitioners, to act as natural persons in their capacity, and also serve as advisory bodies to the institutions that are constituted through legislation or regulation. The various institutions considered are: (i) government institutions; (ii) professional institutions; (iii) legal institutions; and (iii) voluntary/private institutions which have direct links with the construction industry and therefore influence the activities therein.

RESEARCH METHODOLOGY

This study utilised a qualitative research approach in both the collection and analysis of data, due to the vividness of information and novel solutions that this approach provides. This approach is the most suitable

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in situations where research objectives require qualitative answers from professionals with profound knowledge of the phenomenon under consideration (Kruger, 1988). Thus, the data for the study were collected through interviews with experienced and seasoned professionals who have had direct interaction with the adjudication implementation. Twenty-seven experts with intensive involvement in the adjudication implementation from the UK, Australia (Australian states of New South Wales [NSW] and Queensland), Singapore and Malaysia were invited to participate in the research. The UK and NSW experts were selected because both the UK and NSW adjudication regime are considered as leading models of security of payment legislation (Munaaim, 2012). Contacting adjudication experts from Queensland was also considered important to this study because Queensland is the only jurisdiction in Australia that has a dedicated registry in charge of adjudication implementation. It was recognised that these experts in charge of the adjudication registry are knowledgeable personnel with richness of information that they could share to meet the objectives of this research. Singapore was the third jurisdiction selected on the basis of the fact that their adjudication regime is an adapted version of the NSW Acts to suit their own industry structure. Adjudication experts from Malaysia were selected, based on the fact that it was the latest country (as at 2015) that brought into force legislation providing for the mandatory adjudication of construction payment disputes. Apart from this fact, the Malaysian Act is a product of extensive reviews of the range of legislations available internationally (including lessons learnt from practice under those Acts), along with assessments of how best those models might be adapted for use in their jurisdiction (Coggins and Bell, 2015). In effect, the Malaysian Act is a hybrid of multiple adjudication systems and cannot be grouped into either of the other two leading models (i.e. the UK and NSW) (Eversheds Malaysia, 2014). In addition, Malaysia is the only country that named an independent institution called The Kuala Lumpur Regional Centre for Arbitration (KLRCA) as an implementing authority in charge of adjudication administration in their legislation.

Considering the nature of this study, a purposive and snowballing sampling method was chosen to identify the potential interviewees in the four countries selected for the study. The choice of purposive sampling was based on the recognition of the fact that it is the most important kind of non-probability sampling to identify primary participants suitable for the research, i.e. participants disposing of specific involvement and experience central to the phenomenon being studied. The selection of a sample was based on a judgemental approach (Greig and Taylor, 1999). Thus, the methodology employed for this study assumed that what people have experienced is true for them, and that by sharing these experiences, the researcher can enter the interviewee's world (Rubin and Rubin, 2012). In addition to the purposive technique, snowballing methods were also employed. The rationale behind the inclusion of the snowballing technique is that the participants selected through purposive sampling would

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volunteer information on other personnel or individuals who meet the set criteria for selection, and as such, more useful data would emerge that might lead to greater discovery of additional information. The institution in charge of adjudication implementation in Malaysia was the first to be contacted in September 2015. The reason behind this move was based on the fact that Malaysia is the only jurisdiction that requires the administration and implementation of adjudication to be handled by an independent, neutral organisation. Thereafter, individuals who have been involved in adjudication processes and implementation from other selected countries were contacted. Access to the interviewees was negotiated through a letter of request and interviews were arranged with the identified individuals. Fifteen adjudication experts agreed and participated in the interviews. A typical sample size for interviews of this nature is from 5 to 25 individuals (Creswell, 1998; Leedy and Ormrod, 2005; Morse, 1994). Most of the selected participants have had more than 20 years of experience, and have engaged in adjudication as legal advisers, legal representatives, adjudicators, trainers and construction lawyers. In addition, some of the participants have also written books and journal articles on adjudication and payment legislation in their countries and internationally.

Data were collected through interviews via Skype™ in accordance with the Patton's general qualitative interview guide approach (Patton, 1990). The interview guide was developed to enable uniformity in the manner that questions are asked throughout the interview exercise and also to facilitate consistency in the trajectory of the interviews. The questions were to probe the individual's viewpoint regarding the subject matter and the structure of the questions allowed for a reciprocal two-way communication arrangement with the interviewees; thereby giving room for exploratory and clarification purposes (Thomas, 2004). Interviews that lasted an average of 38 minutes were audio-recorded with the permission of the interviewees. The recordings were transcribed and sent back to the interviewees for validation. The data were analysed systematically starting from the formulation of codes, to the development of categories and the creation of themes and sub-themes (Boyatzis, 1998). A total of 412 codes, 41 subcategories, 11 categories and four themes were generated in the study.

RESEARCH FINDINGS

In order to allow quick comprehension of the research findings, the results of the data analysis are presented under two sub-themes. The first sub-theme focuses on identifying the institutions that are involved in the implementation of statutory adjudication and their relevance to the successful implementation of the process. Thus, a question was asked to elicit responses from the respondents as to which institutions are relevant to statutory adjudication implementation. In response to this enquiry, the

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interviewees identified the following institutions, which were grouped into five, namely: (i) legal institutions; (ii) authorising/implementing institutions; (iii) government institutions; (iv) professional institutions; and (v) academic institutions. The general perception is that these institutions must be available and sufficiently empowered for effective adjudication uptake. Participant 12 asserted that the importance of institutions cannot be overemphasised and explained that: "… *their roles* (referring to Adjudication Nominating Authorities [ANAs]) *are very crucial because they are the first organisations that parties go to when they have disputes and they want their disputes to be resolved by adjudication. When you want to refer your dispute to adjudication, they will do the selection and they have to make sure that the people they put on the panel are highly qualified and experienced and they should be able to produce quality decisions as this will impact on the adjudication process*".

The second sub-theme focuses on identifying the roles performed by these institutions. The outcome of the data analysis under this sub-theme revealed that roles are divided among the institutions and each institution's involvement in the implementation is at varying degrees. The general observation is that two out of the five identified institutions (the legal and implementing institutions) are believed to be performing critical and indispensable roles, without which effective implementation of the adjudication process will most likely not be achieved. Interestingly, all the participants from the four countries supported the fact that the success of adjudication starts from effective functioning of implementing institutions in the selection of appropriate adjudicators and the support of the court in the enforcement of the adjudication's decision. In support of the perception that the legal institutions and the authorising/implementing institutions are the most critical institutions participant 4 from the UK commented that: "*The most important institution is the court because they have to support the system. … and if you don't have a supportive court system on ground, the whole process is going to fail*". In line with this comment, participant 7 from Australia pointed out that: "*If a statutory form of adjudication is selected, then the three most important factors are an authorised neutral nominating authority, a good reputable training organisation that can train adjudicators and users, and supportive courts*".

The general observation from the data analysis of the interviewees' responses is that, both legal and authorising institutions have statutory roles which are critical to effective implementation, while other institutions' roles are viewed as non-statutory roles which mainly provide needed support for effective implementation. Participant 13 in this regard stated that: "*Other professional institutions do not perform special roles in the administration of statutory adjudication. You cannot have too many organisations in the implementation of statutory adjudication. It is advisable to have one single body to administer it. Other professional bodies should be supporters because engineers, architects and quantity* *surveyors are the key professionals in the construction industry and they should also be trained to become adjudicators*".

Further analysis revealed a variety of roles performed by the identified institutions in the effective implementation of the adjudication process. The participants were particularly forthcoming in this regard. Initial open coding resulted in 68 different institutional roles. These were later refined and grouped under seven classes, which are: (i) administrative; (ii) publicity and awareness; (iii) education and training; (iv) information dissemination; (v) technical support; (vi) financial support; and (vii) enforcement. In addition to the views that the implementing institutions have the responsibility of general administrative roles, they are equally expected to ensure that the people they put on adjudication panels are highly qualified and experienced and that such people are capable of producing quality decisions. The professional institutions are to be involved in the publicity, dissemination of information and educating their members on the importance and advantages of the adjudication and security of payment regulations. The data further revealed that academic institutions become involved in some jurisdictions by keeping adjudication usage statistics. These statistics are useful for record purposes and tracking of the adjudication progress.

Educating the industry about the proposed legislation and adequate dissemination of information were found to be a vital role and must be adequately performed. Participant 3 described the education role as follows: "*The implementing institution has to engage in very aggressive and proactive educational efforts to explain the adjudication process and its legal framework to all the industry stakeholders, to put into plain and easily understood language the steps needed to conduct an adjudication, to present examples or models of how an adjudication is conducted, and to demonstrate what is expected from the disputing parties when they are making submissions to an adjudicator*". Further, the findings indicate that the rapid acceleration of adjudication implementation in most of the jurisdictions selected for this study was attributed to the publicising, promotion and facilitation of the use of the payment and adjudication legislations by the respective governments. Some of the interviewees also emphasised the need for government to perform the role of sponsoring and funding the implementing institutions in order to effectively publicise, promote and educate the construction industry as to the existence of the adjudication regulations and how they should operate.

DISCUSSION OF FINDINGS

Literature, especially in the field of institutional development, has provided strong evidence for the importance of institutions in predicting the level of development around the world and their significance in the realisation of policy objectives (Blase, 1986; Hall and Jones, 1999;

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Ferrini, 2012). In the words of Blase (1986) "… *institutions play a strategic role in development"*. Thus, developing and enhancing the capacity of various institutions is fundamental to the development of the construction industry (McDermott and Quinn, 1995). A closer scrutiny of the data analysis classified the identified institutions into two groups; (i) the institutional group, and (ii) the organisational group. The perception of the participants is that the institutional groups have critical roles to play in the effective delivery of the adjudication process, while the organisational groups have supportive roles to play. The perception of the interviewees on institutions and organisations was in line with the view of several authors such as Uphoff (1986), McGill (1995) and McDermott & Quinn (1995) who have placed institutions into three categories which are (i) organisations that are not institutions, (ii) institutions that are not organisations, and (iii) organisations that are institutions. Thus, on the one hand, the institutional group in this study falls under the category of organisations that are institutions, and they perform critical roles in the implementation process. On the other hand, the organisational group consists of the organisations that are not institutions, and they perform supportive roles in realising the policy objectives of established legislation. Belonging to either of the groups identified depends on the legislation provisions.

Legal institutions perform basically three roles to promote effective implementation. Firstly, the legal institutions are responsible for the enforcement of adjudicators' decisions. This role is very important for the purpose of ensuring that the policy objectives behind the introduction of statutory adjudication are not thwarted. As revealed from the literature, the functionality of any ADR depends on the relationship between the ADR and the legislation. Where this relationship is absent, the effectiveness is not guaranteed.

Secondly, according to Gaitskell (2007), an effective system of statutory adjudication that will actually achieve the objective of protecting subcontractors' periodic payment cash flow requires not only payment and adjudication provisions, but also a court system which is ready, willing and able to enforce adjudication decisions. This opinion was in tandem with Maritz (2007), who noted that without a coercive method of enforcing decisions, a large proportion of awards granted will simply be ignored. Thus, it is apparent from the findings that the effectiveness of statutory adjudication depends largely, among other things, on legal institutions.

Thirdly, the importance of ANAs cannot be overemphasised. Participant 3 emphasised that: *"There is need of an institution that is proactive and credible. That institution must train qualified individuals to become adjudicators who are credible, ethical, incorruptible and experienced in the subject matters of construction disputes"*. Generally, the nominating authorities are always the first point of contact if parties agreed to settle

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their disputes by adjudication. As such, they are expected to perform some important roles, including accepting adjudication applications from the claimants, providing advice and assistance to parties regarding the adjudication process, nominating an adjudicator to decide adjudication matters, issue adjudication certificates to claimants upon request, and, where approved, to conduct courses for adjudicators (Wallace, 2013).

CONCLUSION

This paper has presented the roles that institutions play in the effective implementation of statutory adjudication based upon a qualitative interview involving experts drawn from the UK, Australia, Singapore and Malaysia. The paper established five institutions that are relevant and that may enhance the effective uptake of the statutory adjudication by performing specifically identified roles. Thus, where the institution(s) that is/are supposed to perform any of the identified roles are non-performing or under-performing, the likely consequences are slow adoption, lack of knowledge of the respective acts and failure of the entire legislation implementation process. Thus certain measures and steps that can promote effective implementation are suggested. Firstly, the role of institutions in the creation of awareness about new legislation is deemed very crucial. As such, all institutions must be involved in the awareness creation as much as possible. For the awareness to have an impact on the various stakeholders, different methods must be adopted at different times over a long period of time, rather than creating large, short-term campaigns that would not have a long-lasting impact. The professional institutions must provide adequate support and be involved in educating their members, be capable of providing effective administrative functions, and be able to rely on the support of courts for the purpose of enforcement of adjudication decisions. Finally, all the institutions must be sufficiently empowered in order to facilitate effective statutory adjudication implementation.

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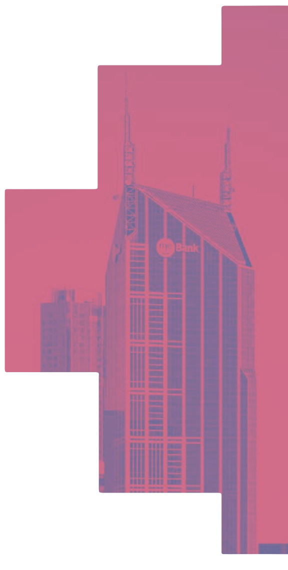

ESSENTIAL SITE COORDINATOIN PROBLEMS IN HONG KONG BUILDING PROJECTS

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ABSTRACT

In Hong Kong, it is a common practice for main contractors to divide the projects into work packages by trade and sublet to sub-contractors. The interaction between sub-contractors and main contractors is an important determinant to the success of a project. However, there is an increasing complaint from sub-contractors that they cannot perform to their full capacity because of poor site-coordination by main contractors. This paper aims to identify and categorize the common site coordination problems in Hong Kong Building Projects. Thirty-eight common site-coordination problems were identified through literature and they were classified into six main categories of problems: Construction document; Site management; Site layout; Equipment support; Material support; and Preparation of site area. A questionnaire survey was conducted to analyze the frequency of occurrence (F.I.) and degree of severity (S.I.) of the problems to the projects. The aggregated importance (IMP.I.), taking into account of the frequency of occurrence and degree of severity, of problems on sub-contractors' time performance were ranked. *Frequent changes of construction works* was found to be the most important site coordination problem. Most of the important problems caused the delay to subcontract works were primarily related to Construction document.

Keywords: Site coordination, Subcontractor, Time performance

INTRODUCTION

In Hong Kong, main contractors tend to sublet most of the works to subcontractors. The subcontracting work packages enable the main contractors to decentralize and minimize potential risk throughout projects and attract the professional knowledge of subcontracting organizations. The good performance of subcontractors definitely contribute to the success of the construction project. However, subcontractors have criticized that they cannot perform effectively on

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site owing to the un-fulfillment of main contractors' obligations by providing good site coordination, which creates dissatisfaction with main contractors and the relationship is deteriorated (Kale and Arditi, 2001). Lack of tools and equipment, incomplete drawings, poor site condition and equipment breakdown were the factors affecting construction productivity, regarded as site coordination problems by main contractors (Kakulsawatudom and Emsley, 2001).

Time, cost and quality are the main criteria for measuring the success and performance of projects (Belassi and Tukel, 1996; Hatush and Skitmore, 1997). Completing projects within the specified period is a symbol of efficiency; hence, time is more important in Hong Kong where fast-speed construction of high-rise buildings is needed. Consequently, it arouses the concern on the construction time of subcontractors.

Most publications for site performance focused at the main contractors' level. Only few studies related to subcontractors performance. The aim of this study is to investigate the influences of the site coordination problems caused by main contractors on subcontractors' time performance in local building project.

LITERATURE REVIEW

The literature review primarily covered similar studies at main contract level so as to attain useful information for this research.

A multitude of publications have analyzed the causes affecting projects delays in construction industry, both locally and internationally. To investigate roots of delay in 130 public building projects built in Jordan during 1990-1997, it developed a regression model between planned and real project duration for various kinds of building facilities (Al-Momani, 2000). It found that the primary reasons of delays were late deliveries, site conditions, designer, economic conditions, increase in quantity, weather and user changes. A research regarding the analysis of causes of work delays for residential building projects was conducted in Indian construction filed (Megha and Rajiv, 2013). It recognized total 59 reasons under 9 categories which were ranked by weighting on project, owner, contractor, consultant, design, materials, equipment, labour and external groups. Consequently, total 4 causes were common in the ranking list, namely shortage in labours, delay in material delivery, low productivity level of labours and delay in progress payment by owner. 56 factors causing delay of projects were identified and categorized into nine prime groups with various degree of significance to different stakeholders (Assaf et al., 1995). In contractor aspect, it outlined that improper contractor finance, shortage of manpower, slow delivery of materials and errors happened during construction were the main causes influencing the delivery of building works. Also, inadequate construction methods used by main contractors and ineffective planning and scheduling of projects had contributions to delay in construction works. Some researches had been conducted to assess the success factors and time performance of Hong Kong construction projects. A hierarchy was developed to indicate causes having major contributions to working duration in Hong Kong (Chan and Kumaraswamy, 1995). Further study related to the causes of construction delays in Hong Kong were done by evaluating the relative importance again (Chan and Kumaraswamy,

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1998). They classified 83 factors controlling construction time into 8 groups, namely plant-related, labour-related, material-related, external, contractor-related factor, design-team–related, project-related and client-related factors.

Thirty-eight site coordination problems attributed by main contractors affecting subcontractors' construction time performance were identified by literature review. They were categorized into 6 groups: Construction document; Site management; Site layout; Equipment support; Material support and Preparation of site area. Table 1 summarizes the literature findings.

RESEARCH METHODOLOGY

Questionnaire design

Questionnaire survey method was used to collect views from the industrial practitioners on the importance of the identified common site coordination problems. The questionnaire has 2 main sections. Section A is used to collect the background information of respondents. For section B, it aims to collect the data to analyze the relationship between the common site coordination problems with subcontractors' construction time performance. Respondents were asked to assign a score from 1 (never happen) to 10 (happen in every site operation) to indicate the frequency of occurrence of the common site coordination problems in their projects. Respondents were also requested to indicate their opinions on the potential impacts of site essential site coordination problems on construction time performance. They would rate each problem from 1 (un-severed) to 10 (extremely severe).

Statistical analysis method

Applying appropriate data analysis approaches is a crucial process in executing a research project (Miller, 1991). In this study, the Importance Index model designed by Assaf and AL-Hejji (2006) and Kadir et al. (2005) was adopted to analyze the frequency of occurrence and the degree of severity of the essential site coordination problems to subcontractors' time performance.

$$\text{Frequency Index (F.I.) (\%)} = \sum a \left(\frac{n}{N}\right) \times \frac{100}{10}$$

In which, a is a constant expressing weighting given to each response (ranging from 1 rarely to 10 always), n is the frequency of responses and N is the total number of responses.

$$\text{Severity Index (S.I.) (\%)} = \sum b \left(\frac{n}{N}\right) \times \frac{100}{10}$$

In which, b is a constant expressing weighting given to each response (ranging from 1 un-severe to 10 very severe), n is the frequency of responses and N is the total number of responses.

Importance Index is a function of Frequency Index and Severity Index that reflects the importance of the essential site coordination problem to time performance of subcontractors.

Importance Index (IMP.I.) (%) = F.I x S.I.

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RESULT

Thirty-three valid replies were received. Around 42% and 15% of the respondents have 6 to 10 and 11 to 15 years of experience in construction industry respectively. All of them were working in construction firms. Around 60% and 40% of the respondents were frontline and management staffs respectively. It is assumed that all common problems have same weighting to their respective category of problems and the index for each category is the mean of the index of all problems in that category. Table 2 presents the result of analysis. In ranking column, it has been classified into 2 types: Ranking (G) shows the ranking of the problems in its respective group whilst Ranking (O) shows the ranking of that group of problem.

Table 1 Ranking of site coordination problems based on Frequency, Severity and Importance Index

No.	Site Coordination Problems	Frequency			Severity			Importance		
		Index	Ranking(G)	Ranking(O)	Index	Ranking(G)	Ranking(O)	Index	Ranking(G)	Ranking(O)
A	**Construction Document**	0.618		1	0.543		2	0.337		1
1	Delay in approval construction process	0.558	5		0.539	3		0.301	4	
2	Delay in providing construction documents and information	0.685	2	(3)	0.533	4		0.365	2	(3)
3	Mistakes and discrepancies in documents	0.630	3	(4)	0.570	2	(9)	0.359	3	(5)
4	Unclear details and specification of information	0.715	1	(1)	0.582	1	(5)	0.416	1	(2)
5	Poor quality document	0.581	4	(9)	0.515	6		0.299	5	
6	Lack of providing documents and drawings	0.539	6		0.521	5		0.281	6	
B	**Site Management**	0.569		2	0.563		1	0.318		2
7	Frequent changes of construction works	0.691	1	(2)	0.618	1	(1)	0.427	1	(1)
8	Late changes of construction works	0.521	9		0.569	5	(10)	0.296	8	
9	Delay in making decisions of construction works	0.552	7		0.527	9		0.291	9	
10	Use improper construction methods	0.576	3	(10)	0.552	7		0.318	5	(10)
11	Use ineffective planning and scheduling of works	0.533	8		0.564	6		0.301	7	
12	Lake of planning construction works	0.564	6		0.587	3	(4)	0.331	3	(8)
13	Frequent reworks or repair	0.612	2	(5)	0.588	2	(3)	0.360	2	(4)
14	Frequent remeasurement of provisional works	0.491	10		0.509	10		0.250	10	
15	Unclear construction orders	0.570	5		0.575	4	(8)	0.328	4	(9)
16	Short announcement of starting site works	0.575	4		0.545	8		0.313	6	
C	**Site Layout**	0.548		3	0.519		5	0.285		3
17	Not ready for providing temporary access	0.589	1	(7)	0.515	3		0.303	2	
18	Not convenient for temporary assess	0.515	6		0.467	5		0.241	6	
19	Lack of space for constructing temporary facilities	0.551	2		0.491	4		0.271	5	
20	Lack of space for working	0.538	5		0.539	2		0.290	4	
21	Lack of space for storage	0.550	3		0.552	1		0.304	1	
22	Use distant location for storage	0.545	4		0.552	1		0.301	3	
D	**Equipment Support**	0.516		4	0.525		4	0.272		4
23	Not available for equipment	0.532	2		0.521	3		0.277	2	
24	Use inappropriate equipment	0.485	4		0.521	3		0.253	5	
25	Use of out-dated equipment	0.509	3		0.533	2		0.271	3	
26	Frequent breakdowns of equipment	0.509	3		0.503	4		0.256	4	
27	Late delivery of equipment on site	0.582	1	(8)	0.576	1	(7)	0.335	1	(7)
28	Provide low productivity and efficiency of equipment	0.479	5		0.497	4		0.238	6	
E	**Material Support**	0.504		5	0.533		3	0.271		5
29	Not available of materials	0.473	3		0.491	5		0.232	4	
30	Use inappropriate materials	0.455	5		0.485	4		0.221	5	
31	Late delivery of materials on site	0.611	1	(6)	0.581	2	(6)	0.355	1	(6)
32	Frequent damage of materials	0.466	4		0.509	3		0.237	3	
33	Provide poor quality of materials	0.514	2		0.600	1	(2)	0.308	2	
F	**Preparation Of Site Area**	0.492		6	0.510		6	0.252		6
34	Delay in providing temporary supports	0.484	3		0.479	3		0.232	3	
35	Insufficient or improper temporary supports	0.527	1		0.568	1		0.299	1	
36	Delay in providing services from utilities	0.508	2		0.558	2		0.283	2	
37	Insufficient or improper services from utilities	0.473	4		0.473	4		0.224	4	
38	Improper site reference points	0.467	5		0.473	5		0.221	5	

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DISCUSSION

Frequency of Occurrence (F.I.)

Table 3 shows those problems with Frequency Index higher than 0.6 in a descending order of priority.

Table 3 Most frequently occured problems

Ranking	Problem	Frequency Index
1	Unclear details and specification of information	0.715
2	Frequent changes of construction works	0.691
3	Delay in providing construction documents and information	0.685
4	Mistakes and discrepancies in documents	0.630
5	Frequent reworks or repair	0.612
6	Late delivery of materials on site	0.611

Three out of six most frequently occurred essential site coordination problems are related to Construction document group. The mean index of this category is the highest (F.I. = 0.618). *Unclear details and specification of information* is the most frequently occurred problem (F.I. = 0.715). This result is in line with the finding of Battaineh & Odeh (2002) and Sambasivan (2007). In local building construction industry, the project duration is critical because of high land price (Ng and Price, 2002). With very tight project schedule, main contractors have to finish a number of activities on time with little time to comprehend the required construction documents and to manage the subcontractors. High quality information should be resulted from careful gathering and analysis with teams, scrutiny of recorded information and manipulation of data through software (Hampson and Mohamed, 2002).

Frequent changes of construction works is the second frequently occurred issue (F.I. = 0.691). It is quite common that client changes their project requirements frequently and also they always underestimate the impacts to the project. Design changes may happen frequently in architectural, structural, plumbing or site work perspectives of building works (Hampson and Mohamed, 2002). Also updated information may not be available to subcontractors on time due the multilayered subcontracting system.

A research about significant factors causing time-overrun was conducted in Hong Kong building projects (Dissanayaka and Kumaraswamy, 1999), it was found that 'Levels of complexity due to changes: Frequency and significance of change order or variations' gained a high Significant Level (0.95), which is similar to the finding of this study.

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Frequent rework and repair (F.I. = 0.612) is another frequently occurred problem. In a report in Chile, it mentioned that the general types of repairs may be defined as changes of working orders, design errors or lack of project definition (Rivas et al., 2011). Also, he found that on-site errors and misunderstandings may cause reworks. Some construction works carried out by main contactors may not meet the standard of Code of Practice. Sometimes, to lower the cost, main contractors may use inconsistent equipment rather than those approved by supervision team, causing progress delay to subcontractors with little time usage and reduction in productivity.

Late delivery of material on site is another main concern. Material is so important to a project that in general accounts for 50% of project sum. The cause to this coordination problem is complicate as it involves the control at various stage of material acquisition including procurement, inspection, transportation, handling and storage before and during construction.

Frequent damage of materials problem has the lowest index (F.I. = 0.466).

Degree of Severity (S.I.)

The top five severe problems are shown in Table 4. Three out of the five most severe site coordination problems are related to Site management group. This category has the highest mean severity index (S.I. = 0.563) in the study. In this category, S.I. of *Frequent changes of construction work* is the highest. About a research about the percentage of changing construction costs to final project cost, 40% of all construction projects undergo more than 10% change, as measured by the ratio of final project costs to estimated project costs. When change exceeds 20%, productivity would fall below planned rates. For the statistic on rework value, the study also realized that the gross value of rework and repair was up to HK$48.3 billion contributing to over 53.6% of whole construction market in 2006, revealed the seriousness of it (Polytechnic University of Hong Kong and the University of Hong Kong, 2008). Poor planning and interfacing works frequently leaded to changes of works and rework.

The S.I. for *Providing poor quality materials* (S.I. = 0.6) is the second highest. Ng & Price (2005) had the same opinion with this result. Many local sub-contractors are employed under the labour-only contractual arrangement such that they could hardly finish the works on time without the steady supply of adequate quality of construction material.

Improper site reference points is the least serious problem to subcontractor's time performance that is mainly because most main

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contractors have already established a professional site surveying team to tackle the setting-out works for projects (Ng & Price, 2005).

Table 4 Top five severe problems

Ranking	Problem	Severity Index
1	Frequent changes of construction works	0.618
2	Provide poor quality of materials	0.600
3	Frequent reworks or repair	0.588
4	Lake of planning construction works	0.587
5	Unclear details and specification of information	0.582

Importance Index (IMP.I.)

Importance index (IMP.I.) is calculated by combining the index of Frequency of Occurrence (F.I.) and Degree of Severity (S.I.). Problems with IMP.I. higher than 0.25 are regarded as important problems.

As shown in Table 3, 20 out of 38 common site coordination problems have IMP.I. higher than mean index (0.294). Top 10 most important problems are presented in Figure 1. Top 5 ranking problems are selected for discussion.

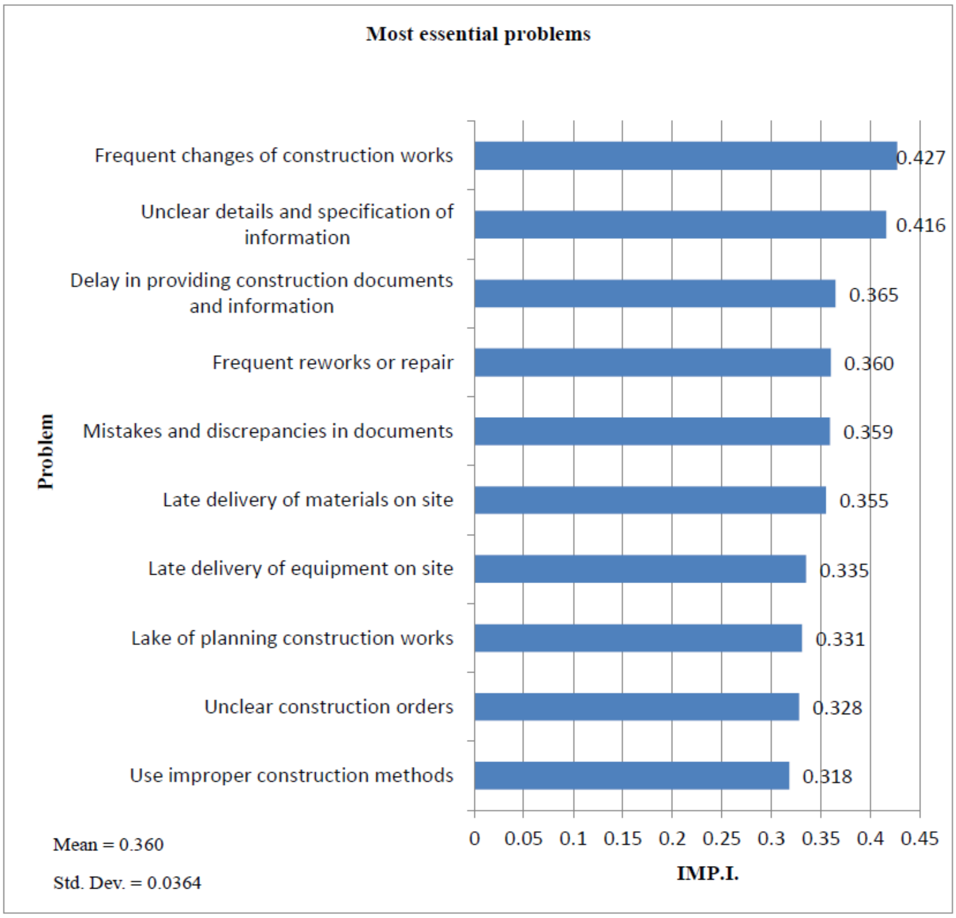

Figure1 Most Important Problems

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Frequent changes of construction work and *Unclear details and specification of information* are the top two important site coordination problems that adversely affected subcontractors' time performance as both of them have IMP.I. higher than 0.4. These two problems happened frequently at local building works and also had significant impact to site works. Five out of top 10 problems are related to Site management. Three out of the top 10 problems are under the Construction documentation group. This indicates that these two groups of problems have significant contribution to the delay of the subcontractor work.

Frequent changes of construction works is also closely related to frequent reworks and repair problem. Construction errors in HK projects demand frequently reworks which were mainly due to poor skills and experience of the operators of main contractors on site work (Palaneewaran and Ramanathan, 2007). Late discovery of the errors would have significant impacts on subcontractors' time performance.

Unclear details and specification of information (IMP.I. = 0.416) and *Delay in providing construction documents and information* (IMP.I. = 0.365) are the second and third important problems. The amount of subcontract packages in local building projects is summarized to around 17 to 54 (Lai, 1987). Under this colossal multi-layered subcontracting system, main contractors' instructions may take a long path to pass through several layers of subcontracting before reaching the workers that are directly responsible for the production works. Owing to the long-path communication path, the content of the instructions may even be misrepresented.

Mistakes and discrepancies in documents is also an important problem affecting subcontractors' time performance (IMP.I. = 0.359). However, from Table 3, its degree of severity is slightly low (S.I. = 0.57). Most of the local main contractors have already well established their document control system under ISO 9001 system as it is a mandatory requirement of most of the government projects. However, due to rapidly increasing of project complexity in terms of design and scale of work as well as very short preconstruction preparation time, this problem occurred frequently leading to high important index.

CONCLUSION AND RECOMMENDATION

The ranking of the site coordination problems aims to provide information for main contractors to prepare guideline to better coordinate the sub-contract works on site. Thirty-eight site common site coordination problems caused by main contractors that adversely affected sub-contractors' time performance in local building projects have been identified through literature review,

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which were then classified in six groups of problems. Through questionnaire survey, the frequency of occurrence of these problems and their degree of severity to time performance of subcontractors were investigated. Aggregated Importance Index of the problems was calculated for ranking their importance on subcontractors' time performance in local building project. This study has identified seventeen frequently occurred problems. Among them, *Unclear details and specification of information* is the most frequently occurred one. Twenty problems were found as having significant impacts to subcontractors. *Frequent changes of construction works* and *Poor quality of materials* are the most essential problems. In the Importance Index analysis, *Frequent changes of work* was found to be the most important problem whilst *Improper site reference points* is the least important problem during construction stage.

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IMPROVING AUSTRALIAN COMMERCIAL PROPERTY MARKET FORECASTING BY MAPPING STRUCTURAL CHANGES IN BUILT ENVIRONMENT

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ABSTRACT

Property market forecasting is an integral element of decision-making. It is critical that property analysts employ a wide - range of models and techniques for property forecasting. These models have one overriding aim of predicting reasonable estimates of key dependent variables (demand, supply, rent, yield, vacancy and net absorption) based on the independent variables of core economic activities. However, a broad-fronted social, economic, technical, political and ecological evolution can throw up sudden, unexpected shocks that result in a possibility of sceptical to unknown risk factors. These structural changes decrease, even eliminate predictability of property market performance. Hence, forecasting beyond econometrics is raised as the research problem in this study. This study follows a qualitative research approach, conducting semi-structured interviews with open-ended questions. The primary data were collected from 22 property stakeholders within Australia. Structural changes framework in the built environment is developed and categorised under PESTEL (Political, Economic, Social, Technological, Environmental, and Legal) factors. This framework was developed theoretically and subjected to empirical validation and improvement. Property conversions, integrated property functions in a single location, 'Give and Take' effect in property markets, NABERS compliance could be seen as emerging structural changes in the Australian commercial property markets. The understanding of the impact on the property market will provide a subjective overlay to improve the econometric forecasts.

Keywords: Built Environment, Commercial Property Market, Forecasting, Structural Changes.

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INTRODUCTION

Real estate assets are characterised by lumpiness and illiquidity involving high unit cost that make decisions irreversible. In Australia, it is significant that direct commercial property investment transaction volumes is amount to approximately 8% of GDP (JLL, 2016). As real estate forms a major part of the mixed asset portfolio, it is critical that analysts and institutions employ a wide - range of techniques for forecasting the performance of real estate assets. Murray, Abelson, and Joyeux (2000) revealed the popularity of single and simultaneous equation regression models over univariate methods. These property market models have one overriding aim of predicting reasonable estimates of key dependent variables (demand, supply, rent, yield, vacancy and net absorption rate) based on current information.

All the stakeholders in the property market have a strong interest in forecasting. As their profitability and success depends on the reasonable estimates of key performance variables (Ball, Lizieri, and MacGregor, 1998; Brooks and Tsolacos, 2010). Accurate predictions can be conducted in a situation when ample quantitative data are available with a few uncertainties. For this type of problem, statistical methods can be employed for standard risk analysis (Aven, 2015).

However, a broad-fronted social, technical and ecological evolution can throw up sudden, unexpected shocks that result in a possibility of regression from Known back to unknown (Bardhan and Edelstein, 2010). However, the independent variables of core economic activity, and the possible disruption from structural changes and Black Swan events can make the econometric results sceptical to unknown risk factors. These extreme downside risk events have been often considered as statistical outliers in real estate modelling. Hence, the success of modern financial risk management in many instances are associated with understanding and managing extreme risk events (Higgins, 2014).

Therefore, modelling of the long-run trends and short-run fluctuations in the property market has become a great challenge. In addition to the reliance on underlying macroeconomic indicators, short term Black Swan events and long term structural changes and transformational forces are another two drivers that may impact upon real estate forecasting (Higgins, 2014). This research objective is to identify the structural changes in the built environment and map their potential impact on commercial property market performance. To do this, the research involved qualitative data collection from semi-structured interviews with 22 property professionals.

The understanding of the impact of structural changes in the Australian commercial property market will form a basis to give recommendations to adjust forecasts accordingly. The structure of this paper begins with a review of literature on structural changes to map the structural threats in the real estate environment. The next section presents the research methodology followed by qualitative data analysis. The last section provides the concluding remarks

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STRUCTURAL CHANGES

Structural changes take place in response to the changes in core drivers of the economy, which is primarily concerned about the distribution of output across sectors, industries, states or regions (Productivity Commission, 2013). According to Prescott (2006), there must be a change in one or more of the four key variables: endowment, technology, preferences and institutions. Endowment refers to the factors of production available to the production process at a point in time. Technology includes the knowledge embodied in the hardware as well as intangible factors such as management practices and know-how. The preferences, refer to the consumer's utility level for different goods and services, in different quantities and combinations. The fourth one 'institutions' refers to the set of laws, rules and regulations, governance frameworks and policies. These sources of structural changes positioned a new equilibrium on the production frontier.

In the real estate sector of the economy, structural changes in property market impact the future use and demand for real estate globally over years and decades. Since 1993, the University of Reading has undertaken an annual survey of corporate real estate practice. A longitudinal analysis over a long period enabled a detail analysis of the major trends in the corporate real estate. Gibson and Luck (2006) identified four major trends in corporate real estate: new working practices, outsourcing, technological infrastructure and corporate real estate management and strategy. According to Bardhan and Edelstein (2010), major structural changes in real estate are driven by a number of economic and non-economic factors: socio-cultural, technological developments, economic/regulatory changes, changes in financial systems.

Additionally, demographic factors such as growth of the population, household formation and ageing demographics of the population (McMahan, 2006; Rowland, 2010) and environmental factors such as land degradation, responses to the climate change and preferences for green concept towards sustainability were discussed under structural changes in real estate (Rowland, 2010). Haynes and Nunnington (2010) introduced six sector approach to categorise each driving forces into demography, society, economy, governance, technology and environment through environmental scanning. The historical background of real estate frontier highlights how several non-economic sources of uncertainty have interacted with real estate market and driven into major changes, for examples: development of property rights, massive rural-urban migration, changing feudal structure, industrial capitalism, evolution of the structure of family, creation of specialised real estate, technological advances such as the invention of new material, advanced engineering techniques and the development in the field of finance leads to the emergence of modern finance (Bardhan and Edelstein, 2010).

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Megatrends tap into sustained evolutionary trends that impact at a global level across PESTEL factors. Although these factors influence real estate performance, the extent and timing of changes are generally hard to predict. Yet, real estate investors need to consider the industry drivers of a city's economy in order to anticipate the scale and nature of demand for real estate, and gain benefits of structural changes (Rowland, 2010; TIAA Henderson Real Estate, 2014). Adhering to the understanding of the available literature, PESTEL approach is used to sort these changes in the real estate environment as summarised below in Figure 1.

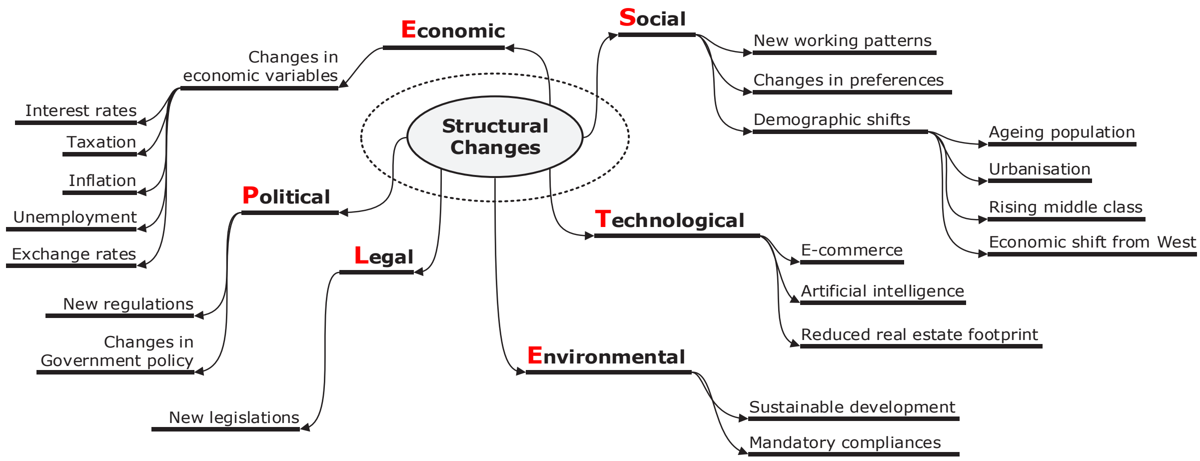

Figure 1 Conceptual Map of Structural Changes in the Built Environment

Given the emphasis to the specific structural changes in Figure 1, the most significant macroeconomic medium that affects real estate is through the credit market via interest rate. The impact is significant due to higher gearing levels which significantly add to the cost of capital. In terms of technological forces, globalisation is a driver of the real estate economy with increasing economic and financial integration whilst brings an elevated risk of contagion (Bardhan and Edelstein, 2010). Further, Sustainable development as an environmental structural change has given prominence under four coherent push factors: financial motivation (Corporate Social Responsibility), government interference (tax credit schemes), standardisation and harmonisation indicators (green building rating systems) and empirical evidence (Lützkendorf and Lorenz, 2005).

RESEARCH METHODOLOGY

In the real estate context, Clapp and Myers as cited in Leishman (2003) stated that the form of deductive reasoning has dominated the real estate economics research since the 1960s which focus on the construction of sophisticated models using quantitative techniques. The change in the research paradigm has been forwarded with the idea of behavioural real estate market research in order to capture the qualitative information. Ball et al. (1998) described the research belonging to this agenda as 'behavioural institutionalism'.

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Hence, this research falls into critical realism philosophical orientation focussing on what we see and experience, in terms of the underlying structures of reality in the Australian commercial property market. The methodology employs inductive reasoning that involves collecting qualitative data from semi-structured interviews among 22 property professionals: property analysts (9), economists (4), fund managers (7) and lenders (2). Property analysts and economists provide real estate research and advice to fund managers for their direct property investment decision making while lenders provide the financial assistance.

This qualitative research inquiry involves four key interview themes: (i) current forecasting practice, (ii) forecast errors, (iii) factors beyond econometrics and (iv) proactive strategies to improve forecasts. This paper presents the analysis of the factors beyond econometrics and their impact on commercial property market. The qualitative data generated from interview transcripts were analysed thematically. Major themes and sub themes were formulated in accordance to requirements of the research objectives using QSR NVIVO 11 software.

ANALYSIS AND DISCUSSION

Through the literature review, a number of reasons were identified to explain potential changes in the property sector and classified under PESTEL framework. This section synthesised the primary data to explore the structural changes more specifically in Australia to validate the conceptual map illustrated in Figure 1. Further, the practical impact of improved forecasting for the property sector is also highlighted.

Political and Legal Structural Changes

Interview participants when questioned about asserted that political shifts and policy changes are unpredictable and there is a quite high risk involved in investment decision making due to political fluctuations. Most experts interviewed indicated that it was getting harder for econometrics to stick in a dummy variable to anticipate structural changes. Thus, investors are being driven to invest accordingly with the shocks from a macro level.

Further, inherent characteristics of the direct property market have been a contributing factor in cascading the impact of the structural changes. A property analyst emphasised the incapability of the inelastic supply to match with the rising demand due to political and legal pressures:

"Things like changes in the planning regime, changes in rules about cross-border capital flows. If the Chinese decide to clamp down on flows of capital out of Chin…those shocks can be quite important for property because property tends to be a very inelastic and fixed asset, it doesn't react very well to changes in demand. Inherently there's always a risk in

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property which you can't do very much about" (Property Analyst).

Economic Structural Changes

Most of the participants raised mining boom as a key structural change in the Australian economy. Apart from that, interview respondents have identified following economic structural changes.

- The rise in the dollar leads to the destruction of the competitiveness of the dollar exposed industries.
- Office and industrial are almost cyclical assets over the retail industry. Therefore, fund managers tend to focus on retail over the other commercial property asset classes.
- Employment as a key variable in the macro-economics is subjected to high mobility with new industries come along and change the movement of the workforce.
- A higher degree of outsourcing and subcontracting of professional services to smaller firms is apparent with the strong growth of smaller tenants who would lease less than 1000m^2 of space. Whilst larger firms are adopting more efficient work space configurations.
- The change in the function of the property product through conversions is becoming a trend.

Further elaborating the property conversions, there is an increased tendency of office properties in the inner ring suburbs of Australian market is converted to residential apartments, student accommodations and hotels. Further, industrial buildings in the middle ring are likely to convert to residential. The following quotations from the respondents provide the reasons for these conversions for property products.

"Office markets such as North Sydney or down in Melbourne St. Kilda Road which were traditionally the second largest office markets in the CBD. Their importance in office marketers has diminished over the last 5 years, I've seen a number of properties being converted to residential, their stocks fallen for by some of 20%" (Lender-Property market)

"As a response to a lot of vacancy in a B grade office building next to our building …………… they decided to let's just change the building and it's all student accommodation they started putting in kitchens and bathrooms everywhere. Then the person across the road, just went - that's a great idea, let's do the same" (Property Fund Executive)

"Industrial areas in the middle ring suburbs surrounded by residential: Footscray, Sun-shine coast going to be residential soon" (Investment Managed Fund Executive)

These structural changes reflected in the macro-economic indicators such as exchange rate, national income, unemployment rate. However, the

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movement in 10years bond rate has not been significantly identified in the interview survey. Yet, the participants emphasised the fact that the Australian economy is in a structurally low interest rate environment.

Social Structural Changes

All the participants affirmed the direct correlation of the population growth to the retail demand. Economists' forecast on population is factored in retail spending and subsequently the demand side net absorption modelling. Younger demographics and their wide internet absorption has become a push factor for the retail market improvement.

Infrastructure development is another key contributing factor to retail and industrial demand. Population growth is driven by infrastructure growth and vice versa. For instance, declining travel costs due to infrastructure improvement means suburbs in outer ring become more valuable (e.g. Bendigo). The similar cyclical relationship could be seen in between industrial demand and infrastructure development. This is justified by the following response of an interviewee.

> *"Industrial property is all about logistics and labour, goods and infrastructure. The most significant feature in property is infrastructure. Infrastructure is investments………That is a materially significant feature, more than the other emerging features that haven't changed us anyway. It has changed where we invest in the industrial"* (Property Analyst).

As another social shift, it is apparent that the integrated property facilities are delivered in buildings in addition to the core function of the building. Today's shopping centres do not merely serve the core function, but also integrate more non-retail facilities such as restaurants, entertainment areas. It is more like a social club, allowing people to socialise.

The same theme has been applied in the office environment, with the key purpose of differentiating the product. For example, respondents highlighted the need for employers nowadays to provide washrooms, lockers for employees riding to work on bicycles and likewise other supportive facilities within the office complex to cater for employee wellbeing. That helps attracting the tenants. However, this strategy is getting replicated among the rivals.

Technological Structural Changes

All three key sectors of the commercial property market were impacted by the factors illustrated in the conceptual map: e-commerce, reduced real estate footprint and artificial intelligence. These factors drive the performance of retail, office and industrial markets respectively. The respondents have agreed upon the transformational forces and further discussed about the status of real estate impact.

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The online retail sector was profoundly deemed to being a substitution to the physical market. However, online retailing has not really made that much redundant in the physical asset. Penetration of eCommerce in Australia has been slower than other global markets. As per the Citi Research (2016), despite its strong growth in recent years, eCommerce sales were only about 4.5% of total retail sales. Whereas according to National Australia Bank (2016) analysis the impact of online retailing is 7.1% of bricks and mortar sales which means 6.6% of total retail sales. Further, the Amazon effect is highlighted by the respondents and its potential impact on electronic retailers. However, respondents highlighted that further improvement in delivery and transportation structure removes a significant impediment which will be then led to a material impact on retail real estate. In terms of forecasting the retail rental growth, it must be carefully factored retail sales component being modelled to factor the online linkage.

Digital disruption has caused the office market to reduce the average workspace ratio through cloud offices, activity based working, casualisation, floating workstations/hot desking, open plan which allows greater workplace flexibility. This has not been a total industry disruption, but it will only marginalise relatively menial tasks in an office environment. Contrary to the theoretical advantages, participants explained the reality vs. expectation, elaborating that digital disruption has not yet been significant. It is more like 'Give and Take' effect on the office environment as justified by the following quotation.

> *"Companies use their space more efficiently like a lot of companies have hot-desking now ……… I reckon while some sounds good and they're getting down the space requirements but in return they have a lot more break out areas, video conferencing rooms, all that sort of stuff. It's give and take. I don't think there's a huge impact there. I think they'll always be demand for offices"* (Investment Managed Fund Executive).

Irrespective of the expectation of scattered office demand across the region with the technological advancement, office tenants are clustered in the CBDs resulted in high rental growth. Though big companies adhere to more efficient work space configurations, but more flexible new born operators/ start-ups have been a big driver of office space demand.

In addition to the use of artificial intelligence in the industrial market, participants revealed a similar 'Give and Take' effect from retail market (give) to industrial market (take) by offsetting the effects of online retail. The industrial market is benefitted by more demand for logistic facilities.

Environmental Structural Changes

NABERS rating has influence on the way commercial buildings are managed in Australia. It has strongly influenced investment decisions for existing and new buildings. The leasing structure of the Australian

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properties was affected by the mandatory compliance to the NABERS rating. The office sector is also beginning to adopt the green agenda as a marketing tool to let properties. The Property Council of Australia (PCA) includes NABERS Energy targets in its 'Guide to Office Building Quality' matrix. Depending on the requirement, property price is subjected to a premium or a discount. Hence, sustainable development is giving rise to the next industrial revolution.

CONCLUDING REMARKS

Structural changes decrease, even eliminate predictability of the property market. Hence, the research intended to improve property forecasting by identifying medium to long-term structural changes in real estate environment. The conceptual map developed in this research is grounded in the existing body of knowledge in the area of property and interview findings with 22 property experts. These structural changes are categorised under PESTEL factors and forwarded to the empirical validation and identifying the current reality in the market.

As key findings, the change in the function of the property product through conversions, the integrated property facilities in addition to the core function of the building, 'Give and Take' effect in office and industrial markets, NABERS compliance could be emerging structural changes in the Australian commercial property markets. These structural changes must be factored into forecasts without simply relying on the static past. This will form a platform for reliable decision making based on the forecasts. The understanding and mapping of the interactions among the structural changes identified in this research are important for property industry attempting to integrate the information into real estate forecasting. Although, this study is limited to the Australian commercial property market, it can be extended into other real estate sectors.

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VIRTUAL LEARNING PLATFORMS: ASSISTING WORK INTEGRATED LEARNING

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ABSTRACT

Work integrated learning (WIL) assists with the assimilation of theory and practice, ultimately producing job ready graduates with the capacity to engage effectively within their chosen work environment. However, for the discipline of construction management (CM), WIL is often impeded by a range of challenges. First, construction sites are considered high risk environments where safety and liability may hinder work place opportunities. Second, large student cohorts combined with distance delivery where impediments of location and the need for an equitable educational experience arise. Furthermore, with regulatory courses, the potential for on-site identification of building code non-compliances (fire safety) further impacts opportunities. This paper presents Stage 2 of a pilot study: Stage 1 involved the preliminary use of a virtual learning platform to simulate an on-site practical experience for students learning construction management curriculum, specifically courses involving building regulation. To understand whether the platform is suitable as a teaching tool and to further enhance the environment and maximise its potential as a CM learning instrument it was also presented, in Stage 2, to a related discipline (health) student cohort who had completed work experience and had a knowledge of fire safety. The intent was to examine realism and replication of a real world environment. Initial qualitative results favour the environment for its realism, immersion and navigation capabilities. Furthermore, it was considered an effective tool for placing theory into context assisting work integration.

Keywords: virtual reality, construction management, work integrated learning.

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INTRODUCTION

The term work integrated learning (WIL) has been defined as the combination of '…*academic study and formal learning with student exposure to real-world practice settings to better prepare graduates for entry into the workforce*.' (Schuster and Glavas, 2017, p. 56). The advantages of work integrated learning (WIL) are well acknowledged (see for example, Brimble et al., 2012; Stoker, 2015) and has been considered an essential pedagogy within the undergraduate educational setting (Mazhar and Arain, 2015) and this is true for the Bachelor of Construction Management (Building) (Honours) degree at the University of Newcastle where students must complete a mandatory sixteen week placement as a core component of their studies.

Although WIL programmes may provide '…an experiential learning experience in a professional environment…' (Mazhar and Arain, 2015), there are a number of obstacles and barriers that impact upon WIL opportunities. In the realm of construction management, particularly courses associated with building codes and compliance, obstacles may be categorised into three primary areas:

- Industrial risk: in this context risk refers to a concept associated with legal liability from work, health and safety concerns through to issues over confidentiality of material (see for example, Cooper, Orrell and Bowden, 2010; Safe Work Australia, 2015) all of which hinder opportunities for on-site experience.
- Cohort characteristics: large cohort size (>200) combined with mixed mode methods of delivery (on-campus and distance) and the requirement for equity amongst cohorts, renders practical experience opportunities unfeasible.
- Code violations: on-site inspections involving assessment against building codes - even at a student level - may result in the identification of non-compliances requiring notification and remediation by the building owner; thus, availability of buildings for student inspection purposes is often limited.

Virtual learning environments are becoming increasingly popular within the educational setting as a mechanism by which to provide a simulated real world experience for students: overcoming many of the obstacles/barriers facing traditional on-site experiences such as those describe above.

This paper presents the outcome of stage 2 of a pilot study. In stage 1, the environment was presented to a CM cohort who having completed a

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building regulations course conducted a virtual site inspection focusing on fire safety. The intent of stage 2 of the study was to explore the CM student outcomes against those of an associated cohort who had industrial experience and knowledge of fire safety to see how the tool could be further improved to maximise the construction management student learning experience.

VIRTUAL ENVIRONMENTS

Zhang & Kaufman (2013) define a virtual environment as '…*a 3-D computer-generated simulated representation of real-world physical environments*' (p.124). Therefore, they are a method of replicating a real world environment that can then be utilised by a student to explore and learn (Lee and Wong, 2014) within a safe situation.

In the context of an educational setting, virtual environments provide a more versatile classroom compared with traditional teaching methods (Jou and Wang, 2013) and in this manner they add a new dimension to the learning experience as they have the potential to transform the way in which material is delivered: presenting opportunities to enhance student engagement (Maltby and Mackie, 2009; Taylor and Disinger, 1997).

Unique to this method of learning is that virtual environments create a platform for learning in which the there is a belief that the simulated environment is equivalent to the real given they '…believe they are both physically and perceptually inside the computer-generated image' (Taylor and Disinger, 1997, p. 39). For construction management students, particularly those focused on building regulations, realism of the environment may encourage immersion: an ability to fully engage with the environment. In this sense, the virtual environment would emulate a real world environment to capture knowledge associated with conducting a regulatory site inspection for compliance.

CONSTRUCTION MANAGEMENT DISCIPLINE CONTEXT

At the University of Newcastle, the Bachelor of Construction Management (Building) (Honours) degree (BCM) provides students with the opportunity to enter the certification profession: professionals responsible for the enforcement of the National Construction Code which contains the countries regulatory technical building provisions. Thus, from an educational perspective, a comprehensive working knowledge of the NCC is mandatory. ARBE1304 Building Codes and Compliance is one such course that has a primary focus upon the NCC and fire safety requirements; however, the ability for students to implement their theoretical knowledge in a practical sense – conducting on-site compliance inspections - is limited by the obstacles identified earlier in this paper.

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THE VIRTUAL ENVIRONMENT

The virtual environment was created by Smith and Trenhome (2009) using the source engine www.valvesoftware.com. The design involved creation of an environment where evacuations related to fire emergencies could be practiced. The environment was based on a three storey building and included materials and graphics to create realism.

In stage 1, the environment was modified for the construction management cohort to create an environment that enabled regulatory building inspections to be undertaken (refer Figure 1). Changes to the environment focused upon fire safety including removal of exit door signage.

In stage 2, the original environment was presented to participants so that they could navigate around the environment and provide feedback on areas such as realism to the working environments of which they had operational knowledge and experience (refer Figure 2).

Figure 1 Modified environment presented to construction management cohort

Figure 2 Environment presented to associated discipline cohort

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METHODOLOGY: STAGE 1

The initial stage of the pilot study involved CM students who had completed the course ARBE1304. Participants were presented with architectural plans and extracts from the NCC along with a series of compliance related questions with a fire safety focus. The CM students were informed that their role was that of a building surveyor where they were to undertake a series of tasks associated with a compliance assessment. Participants were provided with a five minute introduction to gaming through the use of the Unreal Engine (www.epicgames.com) to introduce them to navigation in a virtual environment. Participants were then given twenty minutes to complete the tasks. At completion of the allotted time, participants were individually interviewed to obtain their experiences with the virtual environment and its capacity for use as a teaching tool.

METHODOLOGY: STAGE 2

While the CM student experience with the teaching tool provided valuable information, there was a need to further explore the value of the virtual environment. This need was mandated to ensure that as a learning platform, the tool is representative of the real professional working environment, particularly in relation to areas such as realism and navigation.

In this respect having an associated cohort who had an understanding of real world experience and fire safety, was seen as a beneficial to providing further insight into the virtual environment and its realism.

An associated cohort was recruited and given their role as that of building occupiers who had a familiarity with fire safety. Therefore, the second phase of the pilot study involved second and third year students from the Bachelor of Nursing and Midwifery degree. The participants had all completed intensive WIL as required by their undergraduate programme. Part of this work experience included orientation to fire safety and in particular to emergency evacuation drills involving patients and staff.

Written informed consent was obtained from participants prior to participation. Participants were provided with an office where they were seated at a desk with a desktop computer: Dell Precision T1600 with Dell UltraSharp 24-inch monitor. Their role as a building occupier and more importantly as a health care provider, required navigation through the building and upon hearing the emergency alarm to evacuate as fast as possible. Each participant completed the task three times to replicate the different evacuation scenarios: one exit blocked by fire, multiple exits

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blocked, all exits blocked. A timeframe of fifteen minutes was allocated for the completion of the three tasks.

At the end of the session, focus groups were held to enable the participants to provide their feedback and experiences with the virtual environment. Table 1 provides an example of the types of questions that were presented to each focus group.

Table 1 Example questions from Stage 2

Question theme
• How did you find the navigation of the virtual learning tool?
• Did you find the visualisation of the models as realistic?
• Tell me about your experience of the VR exercise.
• Did you become engaged in the exercise (e.g. forget it was an exercise)? Did this concern you, if so how?
• What were the good points in the VR exercise.
• What do you think we should change or added? Why? How do you suggest we do this?

RESULTS

In Stage 1 all participants performed the set tasks within the allocated timeframe. The feedback was positive and areas such as navigation, realism, curriculum alignment and professional application were highlighted by all participants. Participants identified potential environmental modifications during this stage of the pilot study such as the use of colour coding doors (nominating those that could open and provide egress). Although considered important by students, in terms of WIL it would not necessarily emulate the real world environment as colour coding of doors is not representative of standard building construction.

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Stage 2 involved a total of eight students all of whom achieved the inclusion criteria: year 2 or 3 of nursing degree and completion of WIL. Six of the eight participants completed the set tasks within the allocated time frame. Two participants were unable to complete the evacuation drills related to their inexperience with navigation within a virtual environment. Although these two participants were unable to complete the tasks, they were provided with the same time frame in which to explore and navigate throughout the virtual environment and experience the learning platform. A total of three focus groups were held and as per the first stage, feedback was positive and the tool was identified as one which could assist professional learning. All focus groups highlighted the realism, immersion and navigation aspects of the tool. In addition, the virtual environment was seen to enhance awareness of fire safety. Importantly, there were a number of potential areas of modification that were identified and considered essential to creating a more realistic and immersive environment for construction management students: sound interference, avatars and fixtures.

DISCUSSION

Across both cohorts, it is evident that a virtual environment can be a positive way in which to enhance the learning experience of students. Important areas raised by participants related to the realism of the virtual environment and subsequently immersion capabilities, and the potential for application to both the construction and health care professions.

The realism of the environment was considered extremely positive by both cohorts, in particular the walking and viewing capabilities and building operations such as door movement. The realism of the environment was considered to significantly promote immersion when undertaking the set tasks. Numerous participants across both cohorts made comment as to how the realistic nature of the environment made them feel they were in a real world environment conducting an inspection. Professional application brought forth considerable discussion from both cohorts. The virtual environment was considered a valuable tool to assist integrate theory with practice which aligns with the writings of Lee and Wong (2014) as they explain how such environments provide a mechanism by which to explore and subsequently learn Construction management students, traditionally completed assessments using 2 dimensional drawings and participants commented on the ability of the environment to move beyond such paperwork activities: a tool that enabled replication of professional on-site activities. Similarly, with the nursing cohort the environment provided an opportunity to explore and understand real world practice within a safe environment. Both cohorts agreed that the environment was considered one that would assist students to prepare for professional practice.

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In terms of modifications, the stage 2 cohort raised a number of potential variations that would create a more realistic environment albeit one that may increase the difficulty associated with an assessment task. First, sound interference was raised, a real working building is not void of sound and inspections are undertaken within noisy environments that may impact upon concentration. Secondly, avatars were considered essential. Although regulatory inspections may be undertaken in a vacant building, for example a new build, the reality is that many regulatory building inspections have occupants present and this is particularly true of those involving ongoing fire safety assessments. Therefore, consideration of multiple scenarios would provide construction management students with an opportunity to experience a range of different building environment. This could be further extended to different styles of buildings giving consideration to multiple fire safety scenarios. Finally, additional fixtures were also identified as items that could help create realism. Although some fixtures were included, large equipment would portray a more 'lived in' environment.

The modifications identified by the nursing cohort are important to the future development of the virtual environment. It is also noted that consideration will also need to be given to students who have limited or nil gaming experience. This could be achieved by providing additional buildings in which they can learn gaming navigation skills and prepare for educational training.

Ultimately, virtual reality has the potential to maximise student learning through creation of the opportunity for CM students to undertake realistic regulatory on-site inspections in this flexible learning environment as described by Jou and Wang (2013). Thus, preparing them for industry with the knowledge and experience of the regulatory environment and the role of the certifier and overcoming obstacles set out earlier in this paper.

CONCLUSION

This paper reports on the second stage of a pilot study. The first stage had a focus upon construction management students and their learning around regulatory building codes. In stage 1 a construction management student cohort navigated the virtual environment and conducted a regulatory building inspection to highlight non-compliances. Participants were interviewed to obtain their experiences. In stage 2 a nursing student cohort were required to undertaken multiple evacuation drills within the same virtual environment and then participate in focus groups. The intent being to understand from 'building occupants' - who had industry experience, a knowledge of fire safety preparedness and hence what creates a realistic virtual environment.

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Feedback from CM participants favoured the environment and it was thought that the environment encouraged deeper learning and bridged the gap between theory and context. The associated discipline again favoured the environment and identified numerous modifications that could enhance the learning experience by creating a more 'noisy' working environment – one which simulated an actual occupied and working building.

Due to the inherent difficulties associated with on-site regulatory inspection: industrial risk, cohort characteristics and the identification of code violations, the use of virtual environments as a teaching tool holds promise for work integrated learning programmes. The next stage of this study involves larger cohorts of students to obtain a further understanding of the impact of virtual environments and their ability to assist construction management students.

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IMPROVING BUILDINGS FACILITY INTELLIGENCE IN HIGHER EDUCATION PRECINCT: A SocioBIM APPROACH

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ABSTRACT

Higher education institutions (HEIs) infrastructure asset is a complex and massive investment, with high operational and management cost. The functionality of this infrastructure facility is paramount to the performance and well-being of its users. The effective and efficient operation and management of this facility required adequate knowledge and collaboration of all stakeholders. This study is a preliminary part of a research aim to adopt socioBIM for HE facilities users and facility management (FM) section, to interact with their learning environment and enhance collaborative practice to improve facility intelligence. The study method explores the advancement in building information modelling, decision support systems, and integrator networks based on grounded theory. Conceptually, the adoption of socioBIM reflects an enhancement of users' facility literacy, stakeholder's participation and FM organisational intelligence within HEIs. These will culminate to stakeholder's satisfaction and competitive advantage. Further study is also needful in the efficacy of socioBIM adoption.

Keywords: Building information modelling, facility management, higher education, intelligence, learning environment.

INTRODUCTION

The impact of education in the recent knowledge economies cannot be overestimated. Higher education institution's (HEIs) play a vital role in educational knowledge dissemination that have contributed to the advancement of the society. Tellingly, knowledge generated from HEIs drives and support practice and innovation (Mowery, 2004), and also boost human capital development (Asteriou and Agiomirgianakis, 2001). This knowledge dissemination occurs most time within the HEIs' precinct. The conduciveness of the precinct, determine the level of the influence

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the HEIs objectives has on the stakeholder (students and staff) achievement (Picus et al., 2005) and effectiveness (Temple, 2008). Hence, it can be inferred that HEIs precinct (learning space) must scaffold its envisioned objectives. But, increment in student enlistment, rate of utilization, maturing of buildings and poor FM hone have resulted to increase in facilities problems within HEIs precinct (Lavy and Bilbo, 2009; Olanrewaju, 2012). Unfortunately, higher education (HE) building facility has been concurred less consideration (Riley et al., 2010) and it's failing to meet users prerequisites (Olanrewaju, 2012). Therefore, facility knowledge or the intelligence is needful within the educational precinct for an effective facility management (FM), to maintain a functional conducive learning space.

The state of facility intelligence among the HEIs stakeholder is poor. As indicated by Lavy and Bilbo (2009), there is inadequacy in facilities data in most institutions, because their FM practice for collecting facility condition is inappropriate. In addition, poor quality or fragmented data is a torment of FM practice (Jylhä and Suvanto, 2015).This data deficient has culminated into additional work execution, wasted time, and potential lost in FM administration (Jylhä and Suvanto, 2015), which can add up to organizational catastrophes (Choo, 2005). Facility intelligence sharing is vital within the HEIs to be able to attain the desired facilities performance. Invariable, intelligence is much needful in the conduction of post occupancy evaluation (POE) of the buildings.

The intelligence gathered can improve FM decision making (DM). In addition, learning space facilities information collection technique's and its exactness is basic (Blanchette, 2010), to enhance FM services. Lavy and Bilbo, (2009) acknowledge the fact that facility data integrity can be accomplished with a collaborative FM practice to meet stakeholders needs evaluation and fulfilment. Hence, the development of a platform that can assist and improve intelligence of the facility manager's and other stakeholders is essential in time of dwindling budget, and particularly in public institutions' like the HEIs (Lavy and Bilbo, 2009).

Fortunately, building information modelling (BIM) has been seen as a platform for intelligence sharing within a collaborative forum. Olatunji and Akanmu (2015) stated that BIM enables the integration of multidisciplinary collaborative practice, rather than the formal fragmented FM practice due to its functional characteristics. Also, BIM intention is to facilitate stakeholders contribution and involvement throughout project lifecycle (Motawa and Almarshad, 2015). Hence, a social interaction of facility intelligence sharing among the stakeholders on a BIM platform is vital for the HEIs to maintain functional facilities despite the massiveness of the infrastructure edifice. Therefore, this research aims to conceptualize how socioBIM can be employed to improve facility intelligence among stakeholders in HEIs.

SocioBIM

BIM recently is only applicable to the professional stakeholder and the clients'. BIM adventures covers ability to form usable data and information for simulations and visualizations, and scaffold the collaboration of stakeholders throughout facilities lifecycle by updating facilities data in the model. But, managing built facilities is complex and requires further input from the basic users to inform FM decision making and future designs. Surprisingly, the FM professional have not been fully integrated on the BIM forum during design stage, while the users consideration is beyond the reach. However, to easy the process of POE and performance of built facilities, and to increase users satisfaction, then users integration on BIM forum is needful. This intention lead to the advancement of socioBIM.

SocioBIM is seen as an effective methodology for building users to interact with their building and give profitable remarks and feedback to the building adminstration, because the achievement of asset management and sustainable facility operations, is basically determine by the users, owners and stakeholders (Shoolestani et al., 2015). Further, (Grover et al., 2015) stated the need for a BIM-to-Public platform purposed for integrating users interaction in design and facilities operation. SocioBIM approaches is not just endeavor to make data from BIM available to the public/users for utilization but also to collect input from users, by connecting BIM innovation with technologies of social interaction network (Shoolestani et al., 2015). The information provided assist in operational efficiency of the facilities. According to Shoolestani et al*.* (2015) socioBIM gives the users capacity to:

- Comment on functionality, performance and usability of any building elements
- Comment on the condition and maintenance of the building
- Comment on the design and adminstration levels
- Comment on the indoor and socio environmental condition
- Express their well being and working condition (health issues and productivity)
- Proposed and suggest solutions to facilities problems
- Comment on the asethetic and appearance
- Give their apparent value of sustainability highlights

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- Make suggestions for upgrades and improvement, with attach significant videos and voice updates, photos or any needful document to the remarks.

The accomplishment of these tasks in HEIs will approximately improve facilities intelligence and POE in the sector. It will also support and ease all FM functions.

FACILITY INTELLIGENCE AND SocioBIM

The purpose of the socioBIM for HEIs is to give more precise facilities knowledge to the students, staff, visitors and vendors operating in the precinct. Facilities utilization optimization is paramount. The lack of facilities knowledge compromise the effective utilization and performance of the facilities, invariably affecting users behaviour and performance. The understanding of how facilities function, when they function, where they are located, and why they function in a particular way, of each elemental part of a building necessiate a need for a communicative and collaborative platform for intelligence sharing. In addition, facilities history, manufacturer instructions, key performance index, and other valuable information will assist facility managers in decision making, while other users can interact more with the learning space intelligently.

Intelligence is the ability to learn quickly and cleverly, collect information and solve problems. Facility intelligence is the combination of the ability to learn, recognised, collect facility data and solve facilities' problems. Its incorporates informal and formal learning from education, experience and training, defining facilities problems clearly, fashioning products, and accomplishment of facilities complex tasks and projects (OTEC, 2007) . Facility intelligence is also the application of knowledge or enablement to integrate the people, workplace, and facilities for effective performance. Furthermore, facility intelligence is the custodian, sharing and appropriate use of facility data/information within an organisation.

The need for building facilities information is vital. But, facility data is lacking for management decision in most HEIs (Lavy and Bilbo, 2009). In fact, design and construction of HEIs space has not been informed by input from appropriate users (Germany, 2014), due to inadequate communication flow. Lehtonen (2006) opined that poor communication may cause unfavourable impact on user's satisfactions and relationship with services providers'. This mandate the need for intelligence networks among the stakeholders to enhance organisation effectiveness through socioBIM.

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SocioBIM INTEGRATORS

Building information model (BIM) and game engines: The BIM platform is the major coordinating interface of this integration. The platform will allow the forum for the collaborative practice between all the stakeholders. The BIM will facilitate visualisation, identification and space planning and so on. Addition of gamification platform will allow users interaction within the 3D view (Edwards et al., 2015).

Smart devices and social media: Smart phones and tablet computers integrated with BIM gives simplicity of way-finding, location identification, and visualisation of components (Kim et al., 2013). Social media tools such as online forum, social network, video sharing and blogging can also be employ to engage users with BIM (Grover et al., 2015).

Graphical users interface (GUI): GUI enables the integration of occupants/users of the building into the POE platform to improve collaborative practice. The GUI platform creates a mode of communication between the users and the facility manager. The communication cycle comprises of check and control of facility performance by the occupants and their feedback to the facility manager. Furthermore, GUI usage concede occupants access to the acquired hourly data with analytical and graphical capacities on a web-based network (see Göçer, 2014).

Energy information system (EIS) and sensors: Intelligent adaptability that encourage the progressive, bi-directional interaction between the occupants and the building is possible with EIS (Göçer, 2014). In addition, EIS facilitates a proactive approach to manage energy utilization by the observation of building performance and accurate data sharing among stakeholders (Göçer, 2014). Diverse sensors have also been employed to gather real time data in buildings to complement BIM (Coates et al., 2012).

Above all, diverse decision support systems will be employed to enhance the capability of the socioBIM platform, and all will be integrated with a cloud network.

IMPACT OF SocioBIM ON HIGHER EDUCATION FM ORGANIZATIONAL INTELLIGENCE

One of the focus of the socioBIM networks in our research is to improve the FM intelligence within HE organisations. To achieve this, we developed a conceptual model based on intelligence theories to illustrate part of the envision impact of sociaBIM in HEIs as shown in Figure 1. Organisational intelligence (OI) is the ability of an organisation to understand and conclude knowledge significant to its business endeavour, so it is the collective intellectual capacity of the entire system. OI is "an

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organisation's capability to process, interpret, encode, manipulate, and access information in a purposeful, goal-directed manner, so it can increase its adaptive potential in the environment in which it operates" (Glynn, 1996). Much have been said about the inability of the building not to meet user's satisfaction and the lack of feedback from users. Besides, it has been shown that FM organisation remain solitary (Kamaruzzaman et al., 2016), which means not intelligence sharing oriented. These networks will allow the participation of the user's in the operation of the building's and giving real time and authentic feedback to FM section. Since all facilities users will be equipped with smart devices, a continuous communication is established for information exchanged on the platform. In addition, users can learn and be conversant with diverse building elements characteristics from the curated BIM model increasing their facility literacy. Further, users can lodge in complains and opinions about any elements which the FM can process as a POE data for decision making (DM). Defects are also easy to identify and indicate on the platform. This openness in data, knowledge and intelligence sharing culminate to the empowerment of the organization, its staff and stakeholders (Schoech et al., 2002).

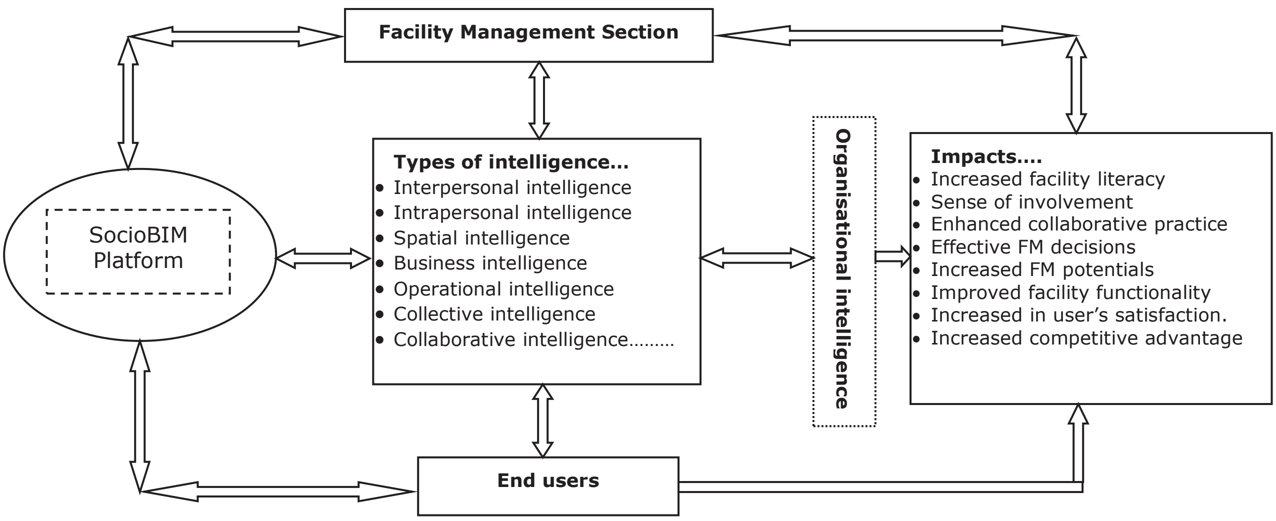

Figure 1 The impact of socioBIM on organisational intelligence and performance.

We envisaged that the deployment of socioBIM can improve the following intelligence in HEIs as illustrated in Figure 1:

Inter/Intra personal intelligence: This is based on Gardner (1983) theory. The platform will make users understand facility elements with their forms and interact with each other's concerning it (people smart about facility). It will also foster interpersonal relationship within the stakeholders where facility debate and discussion is encouraged for better

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decision making. It will drive intrapersonal intelligence by allowing users to express their interests, objectives and needs in HEIs facilities that gives them satisfaction (people self-smart about facility). This will boost user's satisfaction, sense of involvement and facility literacy.

Spatial intelligence (SI): SI concept is based on Gardner's theory. The proposed socioBIM will enhance the stakeholders the capacity to know where they are with respect to a fixed location, and to fulfil tasks requiring three-dimensional visualisation and arrangement. This will enhance the users to advice the FM better on how they want their workplace arrange and request necessary features needful. It will also easy the problem of way and direction findings within the precinct and FM literacy.

Business intelligence (BI): BI is a characteristic outgrowth of a progressive of past frameworks intended to bolster DM (Negash, 2004). The concept of socioBIM serve as a decision support system (DSS) to enhance FM BI based on the incorporation and examination of organisational data assets to improve FM business DM. It will also aid simplification of facility data storage, examination and identification of FM information in enhancing facility information quality for DM in the HEIs FM business. Hence, achieving functional and improved facilities.

Operational intelligence (OI): OI is the utilisation of integrated business management system to enhance internal processes and fundamentally support customer services (Dickinson, 2016). The proposed socioBIM will complement building management system to improve internal procedures and fundamentally boost FM service to users, and position the FM to successfully manage rapid change, and yet maintain positive business change via continuous self-improvement. It will provide real-time elements that conveys visibility and understanding into information which can inform operational directions and motivational tool for FM business.

Collective intelligence (CI): The proposed socioBIM if integrated with web 2.0, crowdsourcing and some social networks tools in gathering collective facility intelligence for decision making gives a task-oriented elements, real-time (or ad hoc) collaboration, and integrate distributed intelligence or knowledge ontologies (Bonabeau, 2009). The collection of facility condition data from users will save time and ease FM functions thereby increasing FM potential.

Collaborative intelligence (CI): The socioBIM will enhance the ability of the facility managers to build, input to and oversee control of networks of stakeholder's interactions to create intelligent FM results. It will facilitate collaborative FM practice. Also create a social collaboration among group of users whose intelligence can be incorporated (Bonabeau, 2009) in FM DM. It will also induce competitive advantage.

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The utilisation of socioBIM in HEIs will facilitate the intellectual capacity of the stakeholders in relation to the learning space facilities and it management collectively. According to Charlesraj (2014), Knowledge based BIM can advance the efficiency and effectiveness of FM system. We believed that the implementation of socioBIM in HEIs will addressed many FM intelligence challenges in HEIs.

CONCLUSION

This study focus on the conceptualisation of how socioBIM can improve facility intelligence in HEIs precinct. The various facility intelligence envisions to be improved are inter/intra personal, spatial, business, operational, collective and collaborative intelligence. As known, HEIs infrastructure facilities management is information intensive, which needs a high-level intelligence input not just from the FM officers but also from users and other technological devices. SocioBIM platform will enable FM collaborative practice in the sector. The awareness of user's contribution to FM decision making (DM) can catalysed individual level and collaborative facility intelligence development. Basically, user's participation increased the efficacy of facility data used for FM DM. Hence, SocioBIM serve as an indicative technology that can improve facility intelligence in HEIs, thereby influence their organisational intelligence, users level of satisfaction and sense of belonging. These attributes culminate to organisational excellence and competitiveness. The conceptual model can be used to inform additional benefits of socioBIM. Also, further study is needful to implement socioBIM in HEIs and validate its efficacy.

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Engineering and Construction Expertise Transfusion at the U.S. Army Corps of Engineers: A KM case study

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ABSTRACT

Knowledge Management (KM) is the collection and transfusion of the organization's critical information, skills, experience, and identity, held by senior individuals, to successor generations for action. A great deal of the technical expertise in the U.S. Army Corps of Engineers (USACE) has been departing through the retirement of the most experienced employees over the last several years and continues to do so today. Without robust technical competency, an organization as large as USACE cannot continue to perform design and construction functions effectively. This research study defines KM, reviews best practices from industry and assesses how USACE is performing at the working level. The research data obtained identified key needs and subsequent recommendations for additional efforts or improvements to existing initiatives. Data was collected through interviews of eight managers at a USACE District Office to make assessments and determine steps to be taken to ensure critical expertise is retained and mission execution continues effectively. This study found that at the working level the current KM program is primarily based on mentoring and informal communities of practice, and not in top-down information systems based approaches. USACE would benefit greatly from reconciling different approaches, eliminating redundant items, and a coordinated approach at all levels of leadership to champion processes that work.

Keywords: Knowledge management, U.S. Army Corps of Engineers (USACE), engineering and construction, knowledge transfusion

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INTRODUCTION

Past literature concluded that innovative practices, experiential knowledge and best practices gained through problem solving becomes a competitive advantage of the construction firms if captured properly on the construction projects (Tan et al., 2009, Dave and Koskela, 2009, Shokri-Ghasabeh and Chileshe, 2014). In addition, knowledge capture overcomes the knowledge amnesia and proves a competitive edge to the project-based organization by overcoming the 'reinvention of wheel' (Dave and Koskela, 2009, Ajmal et al., 2010). Furthermore, the project lesson learned can be reused for future project's problem solving (Schindler and Eppler, 2003, Shokri-Ghasabeh and Chileshe, 2014). As a part of construction supply chain, the construction organizations require new knowledge and innovative approaches to be competitive (Saad et al., 2002, Briscoe et al., 2001, Egan, 1998, Walker et al., 2003). The integrated and collaborative culture developed through the adoption of supply chain practices facilitates problem solving. Project partners reuse and share knowledge by forming the learning alliances (community of practice) on the projects (Khalfan et al., 2008, Walker and Lloyd-Walker, 2015). The collective learnings and innovative solutions, developed through interaction among project supply chain partners, could be adapted into similar contexts for future product innovation and improved products for clients (Dave and Koskela, 2009, Yang et al., 2010).

Emergent situations require the innovative and proactive knowledge management practices to solve the emergent projects situations. In authors view, construction projects day by day are becoming complex, therefore supply chain integration provides a better foundation to solve these emergent situations as well a set a climate for knowledge sharing and collaboration (Oliver and Reddy Kandadi, 2006, Ajmal and Koskinen, 2008, Davenport et al., 1997). As a result of collaboration, firms improve its organizational knowledge and intellectual capital through learning from other project partners (March, 1991, Maqsood et al., 2007, Egbu and Botterill, 2001).

Several studies outline the challenge of knowledge management, particularly knowledge sharing and transfer, within the organization and within construction projects. However, research lacks in the project knowledge capture and its reuse on the future projects (Tan et al., 2009, Shokri-Ghasabeh and Chileshe, 2014). In addition, it is concluded clearly that project management is hampered by work pressure, time pressure and lack of motivation are the impacting factors to capture the project knowledge and experience (Tan et al., 2009, Hari et al., 2004, Bresnen et al., 2003). Furthermore, it has been well documented that knowledge acquired on the project may be lost due to the project team members

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departures (Shokri-Ghasabeh and Chileshe, 2014, Schindler and Eppler, 2003, Egbu and Botterill, 2001).

Knowledge is a combination of information and experience. In the E&C community knowledge has been created by many careers worth of effort and perseverance. Preserving critical knowledge means compiling it and passing it on to successors. Effective KM for U.S. Army Corps of Engineers (USACE) is defined by this study as the collection and transfusion of the organization's critical information, skills, experience, and identity, held by senior individuals, to successor generations for action.

This definition of KM for USACE dictates that to be successful it must be a part of the culture of the organization. Research on the application of lessons learned in the E&C industry by the Construction Industry Institute (CII) provides insight into how the culture of an organization is closely linked to KM. CII describes a learning organization as one that can create acquire share and apply knowledge. These organizations embrace change and innovation which leads to improved performance and competitive advantage. It is clear that while KM can be defined as a system or program, it is equally a part of the culture of an organization. (Construction Industry Institute (CII), 2006). While an organization may embrace KM, define a program and begin implementation, if a cultural shift is needed the process will take a great deal of persistence and time to realize the performance and competitive gains.

The aim of this research is to define effective knowledge management strategies for USACE and provide recommendations for program improvements and enhancements. This study will seek out best practices from within and outside of the engineering and construction industry worldwide, assess how USACE is performing at the functional level and present guidelines in the form of tailored practices for implementation. Three primary objectives of this research study are:

1. Define KM and evaluate best practices applicable to USACE.

2. Analyze the demographics of the USACE workforce as it relates to technical expertise and assesses the current USACE knowledge management program.

3. Develop guidelines for a USACE specific KM Program through the identification of new or improved practices for retaining the knowledge of retiring employees.

This study answers the following:

1. Can USACE retain the technical expertise of retiring employees through a knowledge management program if the workforce continues to shrink and work continues to be outsourced?

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2. What culture, roles and processes are needed to implement a successful KM program?

3. What common components and practices do successful KM programs share and how many of them exist within USACE?

4. If the KM program is lacking key components or is not implementing specific aspects effectively what steps can be taken to include or improve them?

Methodology

This research used a case study method with data collected through interviews with managers at a USACE District Office. The case study evaluated the USACE KM program in comparison to industry, identified positives and minuses and in turn prepared recommendations for more effective current and future programs. Accomplishing the study objectives required an assessment of the implementation effectiveness of KM at the working level within the Corps. Mission execution within USACE occurs at the District office level, where engineering, construction and operations personnel deliver facilities to the military and the nation. A targeted KM assessment had to be conducted based on data from the District office.

Both quantitative and qualitative data analysis was performed to meet study objectives and answer the key questions. Quantitatively compiling the demographic data according to technical sections defined the percentages of employees within certain ranges of retirement. In addition to the time until retirement, this data also demonstrated the years of experience or specific skill sets that will be lost upon those retirements. Interview responses were compiled by a question and analyzed using descriptive statistics. Extracting key terms, themes or activities prevalent in multiple responses was to assess the current KM program and identify areas for improvement. The final step in the analysis was to use the interview data to qualitatively identify unique factors to consider in developing guidelines and recommendations for USACE.

Results and Discussions

This research used data collected from interviews of eight (one recently retired) managers at a USACE District Office. The literature review identified a number of Headquarters (HQ) level goals, plans and procedures to implement an effective KM program throughout USACE. Data from interviews of District office managers established the current culture, practices, software, and other activities that reflect the current KM program and its level of implementation.

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The first two structured interview questions were asked to obtain introductory information and quantitative data related to workforce demographics and retirements. Demographically the Managers interviewed supervise organizations as small as 5 employees to as large as 161. The organizations defined in Table 1 below correspond to each of the managers interviewed. Some of the managers interviewed were Division Chiefs that supervised Branch Chiefs who were also interviewed. These columns take this into account and do not double count workers under a Division Chief that are supervised by one of the Branch Chiefs interviewed. For example, while a Division Chief may have answered that 161 people work in the organization, 80 of them are included under one of the Branch Chief's organization. The total number of staff supervised by the managers interviewed is approximately 351 people. The staff in these organizations is primarily made up of engineers and scientists with additional technicians, budget analysts and administrative support personnel.

Table 1 Current Demographics

TABLE 4.1 Current Demographics	Org 1	Org 2	Org 3	Org 4	Org 5	Org 6	Org 7	Org 8	**SUM**	Avg. Rate[1]
Number of People Supervised	21	30	18	5	108	42	80	47	351	
Number of Recent Retirees	2	5	5	1	12	3	10	5	43	12%
Percentage	10%	17%	28%	20%	11%	7%	13%	11%		
Number eligible or within 5 years	10	8	5	3	40	10	25	2	103	29%
Percentage	48%	27%	28%	60%	37%	24%	31%	4%		
1. Weighted average of all organizations										

The weighted average rate of recent retirees was approximately 12% of the total size of the organizations covered by the managers interviewed. The individual organizational rates range from 10% to 28% in the smallest organization. The percentage of employees eligible or within 5 years of retirement on average across all organizations whose managers were interviewed is 29%. The individual organizations percentage of "near retirement" individuals ranged from 4% in one of the mid-sized organizations to 60% in the smallest organization. Based on these percentages it is apparent that the surge of baby boomer generation retirements is still a significant factor at the District Office studied. Industry estimates found during literature review suggested that as much as 20% of the workforce would be ready to retire in a relatively short span of time in the mid 2000's. The peak appears to be lagging this timeline for the District studied, but in general, the estimate appears to be highly applicable to USACE according to this research. Within the next five years, the data indicates that if retirees are replaced with entry level

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employees and the organization sustains in size the workforce will be younger.

The last four questions in the structured interviews sought to obtain qualitative data on the state of the USACE KM program, learn how KM is being implemented, define the most significant challenges and consider what the future workforce will look like. Since it is clear that the workforce will be younger and generally less experienced, assessing the KM efforts of the District are critical to determining whether the necessary expertise will be available to remain an effective engineering organization.

The third interview question concerned awareness of the various HQ initiatives on KM at the working level. The findings of this study may be disappointing to HQ and emblematic of a common frustration that the working level staff feel towards HQ. The data presented below in Figure 1 includes seven HQ initiatives related to USACE KM, an eight category for "other" responses and a ninth category to capture one comment that was noted in every interview. All (100%) of the managers pointed out that utilization was low on more than half of the HQ initiated programs. While not a specific category of Km initiative the response was so prevalent it was included in the figure below.

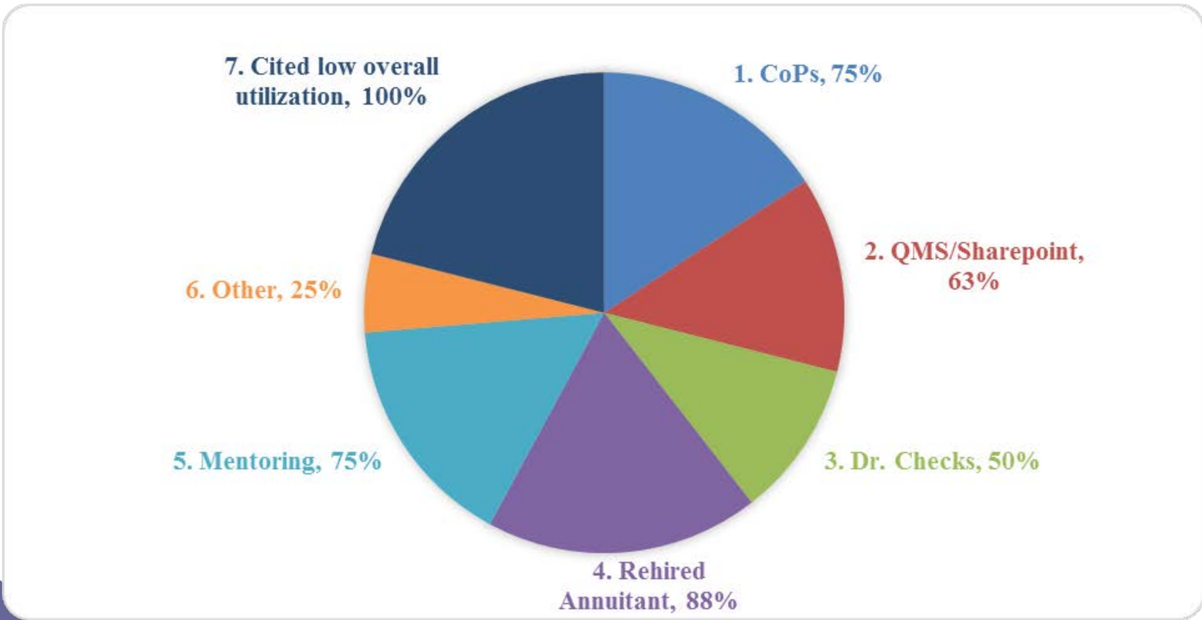

Figure 1: Awareness of USACE KM Initiatives

In the figure above percentages are calculated out of a total 8 potential positive answers for each x axis category. One manager's comments summarized the general trend seen in all the interviews regarding utilization that 'awareness is there but utilization and active participation is lacking.' The responses were not all negative, however. Greater than 60% of those managers interviewed reported a general awareness within

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their organization of CoPs (75%), QMS and other SharePoint collaborative sites (63%), the Rehired Annuitant Program (88%) and some form of mentoring (75%). Dr. Checks was cited by 50% of the managers and "other" initiatives were cited by 25% of the managers. No managers (0%) cited any significant awareness or utilization of the WBDG or the TEN (Technical Excellence Network) sites discussed in the literature review. Raising awareness and utilization of these repositories must become a first step in enhancing the organization's KM program.

One of the interesting "other" responses was an initiative discussed by the recently retired manager. Prior to retirement, his organization conducted a workforce review to assess strengths and gaps in competency so that personnel and training actions could be properly targeted. Workforce assessments were a fundamental aspect of the USACE Strategic Human Capital Management Plan and are another key first step towards improved KM.

Overall, the data suggests that where awareness exists it is within the efforts that involve more direct personal interaction. CoPs, SharePoint, Rehired Annuitants and Mentoring are driven by social and personnel actions. These efforts include more local interaction and are initiated at the working level by project teams or first line managers. The data indicates that while many industry best practices for KM exist within USACE, awareness and utilization of IS based approaches are at best secondary at this time. In the future, if the trend of shrinking workforce continues these approached will become more important to the organization.

The fourth interview question sought to collect effective KM approaches actually being used in practice at the working level. Figure 2 below highlights the six most common categories of methods noted by the managers.

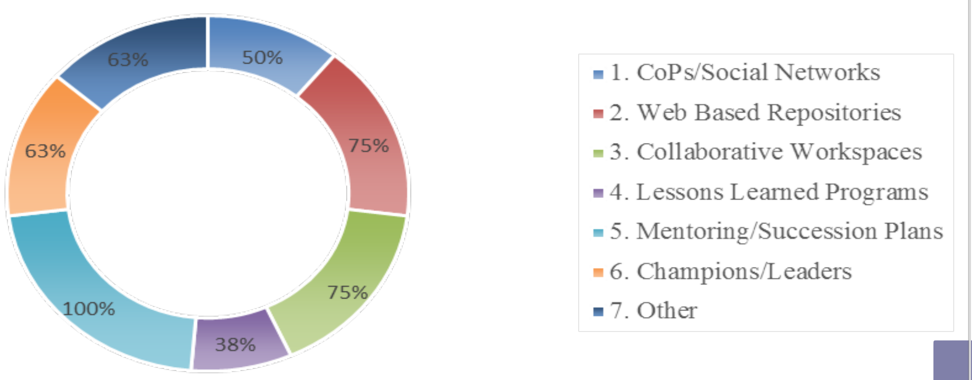

Figure 2: Successful KM Methods

All (100%) of the managers interviewed noted some form of mentoring as a successful means to effective knowledge sharing and transfer practices. About half (50%) of the mangers identified CoPs/Social Networks as being successfully utilized and a strong percentage (75%) of managers cited online repositories and collaborative workspaces. Often linked by the interviewees and closely related to these three items are the need for champions or leaders to promote and manage them, and 63% of managers noted that individuals serving this type of role are an effective means to implement KM. A relatively lower number (38%) of the managers cited lessons learned programs as an effective KM process being used. This is potentially one of the greatest areas for improvement in an organization as large as USACE. With the number of already existing IS based KM initiatives by USACE - WBDG, TEN, Dr. Checks and QMS for example - the addition of a lessons learned database, accessible across Districts would be an excellent process for enhancing the KM program.

At least three managers cited HR processes that enabling the hiring of college students on a part time basis that transition into interns and finally journeyman staff after a set program of 4-6 years. This program enables a work unit to hire the replacement for a senior team member before retirement and possibly have about five years of overlap and development.

Most of the managers cited one or more "other" means by which their work units had implemented KM. At least two managers cited HR based efforts where young workers receive on the job experience through position rotations or temporary assignments to project locations/teams. Additionally, one manager cited inter-agency reviews where design products are reviewed by members of other districts that perform the same basic function. All these "other" responses provide the organization opportunities to create informal CoPs, share lessons learned and perform informal mentoring.

Conclusions

These findings are interesting considering all the data collected and discussed in this paper. It appears the HQ program for KM is not being implemented effectively nor is it well targeted or managed based on the number of initiatives that are not utilized significantly. To be clear the data does not indicate that effective KM is not occurring, it simply may not be following the means envisioned by HQ USACE. These points clearly illustrate that a review of the USACE KM program is needed and it must not be a "top-down" only approach.

The two questions that revealed perhaps the most significant data involve the manager's examples of effective KM and the related challenges. The responses to these questions demonstrated that at the working level USACE has a mentoring based KM program that is effective but could benefit from improvements in the implementation and utilization of lessons learned repositories, CoPs and collaborative workspaces. These three areas appear to lack champions or leadership in the form of individuals at various levels of the organization from HQ down to the first

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and second line supervisor who are responsible for promoting and identifying opportunities where teams and individuals can utilize tools that already exist.

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THE CORE FUNCTIONS OF PROJECT GOVERNANCE

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ABSTRACT

Research in the realm of projects is increasingly turning its focus on governance. Much has been written on the importance of good governance and the clear link between good governance and project success. However, few have delved into delineating the core functions of governance that is central to good governance. In this conceptual paper, we examine existing research ideas and concepts of project governance to develop a framework to add to the knowledge base of this subject. This paper proposes six core functions of project governance. They include (1) determining the objective, (2) determining the ethics, (3) creating the culture, (4) designing and implementing the governance structure, (5) ensuring accountability by management and (6) ensuring compliance. The framework described in this paper can provide guidance to organizations in the development of effective project governance to optimize the management of projects.

Keywords: Project governance, functions, values, project success.

INTRODUCTION

Project-based organizations have become widespread organizational structures. Projects are becoming the main vehicle to achieve strategic objectives and beneficial change (Biesenthal & Wilden 2014). Accordingly, much academic and practitioner attention has been dedicated to achieving a better understanding of the management and governance of projects. One of the major determinants of success is an effective project governance structure (Lechler & Dvir 2010). Good project governance is a precondition for achievement of success and sustainable value for the organization and all the stakeholders involved (Beleiu & Nistor 2015). However, project governance models have lagged developments in the project management literature (Zwikael & Smyrk 2015). Although

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research on governance acknowledges and addresses the nature of governance across the various relevant organizational levels (Foss, Husted & Michailova 2010; Too & Weaver 2014), due to the multiple definitions of project governance found in literature, the exact nature of the project governance construct remains unclear.

The aim of this paper is to examine and explore the functions of project governance. To do this, we examine current literature on governance. Existing knowledge of governance and project governance could be enriched by drawing from the stream of literature addressing projects as temporary organizations (Engwall 2003) within the project management literature. This stream of research is likely to offer valuable insights into the governance of projects as it addresses the complex interplay between the stability of the project-based firm versus the inherent temporarily of the project (Ahola et al. 2014). We investigate how the concepts and themes of dominant corporate governance theories have been applied to the context of project governance. Synthesising these findings, we present a framework linking governance theories with the focus of project governance.

The paper begins with an overview of the relationship between project performance and governance that underlies the importance of governance research. This is followed by a review of the concept of governance and the diversity of views of project governance that warrant clearer descriptions of these governance functions. Based on this literature review, we propose a conceptual framework describing the key functions of project governance. We conclude this paper with a summary of our findings and discussion of future work.

THEORETICAL BACKGROUND

There is a significant growth in the adoption of project management tools and techniques to accomplish work in different sectors and industries (Tsaturyan & Müller 2015). The main purpose of using projects and their associated disciplines is to increase organizational value (Dalcher 2012). Project value refers to the explicit and implicit functions created by the project, which can satisfy the explicit and implicit needs of stakeholders (Zhai, Xin & Cheng 2009). Therefore, project value can be understood in so far as it satisfies customer needs, aligns the project output with the organization's strategy and gives a return on investment (Thomas & Mullaly 2007).

To measure the value created from using projects, governance is increasingly recognized as the key factor to achieve project success (Joslin & Müller 2016; Lechler & Dvir 2010; Muller 2009). Sanderson (2012) argues that performance problems are often a result of misaligned or underdeveloped governance mechanisms, which hinder project actors’

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ability to provide sufficiently flexible and robust response to inevitable turbulence. A good governance structure can therefore reduce conflicts among different groups of stakeholders and contributes to a firm's performance as it helps to manage and minimize project risk, improve transparency between different organizational levels (to meet project objectives), and positively influences the exchange of relevant information across different stakeholder groups (Muller 2009). In other words, good governance is a precondition for the achievement of success and creation of sustainable value to organizations and their stakeholders (Beleiu & Nistor 2015). However, project governance models tend to lag other developments in the project management literature (Aubry, Monique, Richer & Lavoie-Tremblay 2014; Zwikael & Smyrk 2015).

Governance, in general, means 'to steer'. The Organization for Economic Co-operation and Development (OECD) defines governance as: "Involving a set of relationships between a company's management, its board, its shareholders and other stakeholders [...] and should provide proper incentives for the board and management to pursue objectives that are in the interests of the company and its shareholders and should facilitate effective monitoring" (OECD 2004). In its most general form it is defined as a set of rules, (stakeholder) relationships, systems and processes by which authority is exercised and controlled in organizations. It relates to processes and decisions that seek to define actions, grant power, and verify performance (Samset & Volden 2016). Hence, "governance is ultimately concerned with creating the conditions for ordered rule and collective action" (Stoker 1998).

Projects are embedded within an organizational context. Within organizations, "governance of projects" concerns the areas of governance that are specifically related to project activities (APM 2011; Biesenthal & Wilden 2014; Too & Weaver 2014). In fact, projects and project management coexist within the corporate governance framework and therefore refers to the processes, systems, and regulations that must be put in place to ensure that projects are successful and create value for the organization. To this end, project governance supports an organization in aligning its project objectives with its organizational strategy, achieving set project objectives and monitoring performance (PMI 2013; Turner 2009).

Project governance research has started to address governance across the various relevant organizational levels (Foss, Husted & Michailova 2010). Many studies that examine project governance have attempted to provide the definitions of project governance. Some of these definitions indirectly specify the functions of project governance. Some studies discuss a small number of functions. For example, Pinto (2014) describes project governance as "the use of systems, structures of authority, and processes to allocate resources and coordinate or control activity in a project" Other studies have identified and described a very large number

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of functions. Hazard and Crawford (2004) define project governance as "a set of formal principles, structures and processes for the undertaking and management of projects, applicable in the context of individual projects, programs or portfolios of projects which appoint a governor (or governing body) for a project ; define and regulate roles, accountabilities, decision making and boundary management, and coordinate project relationships, planning and control. In between these extremes, there are studies discussing a moderate number of functions; for example, Turner (2009) defines project governance by referring to the relationships between the owner of the project, the sponsor, the project manager and other stakeholders.

In all these cases, many functions are found to be overlapping and interconnected. The diverse definitions within the literature, at least partially, are due to the studies being conducted on various types of organizations active in different industries, such as IT, telecommunications, construction and real estate and the healthcare sector. It is also clear that definitions of project governance are broad and vague, incorporating many empirically identified phenomena. Furthermore, the definitions generally do little to clarify the specific functions that the project governance undertakes. Many studies have also investigated project governance functions without conceptually distinguishing between them, or reflecting on how they relate to each other. Hence, even if a broad range of project governance functions have been investigated and numerous benefits are purported, the understanding of how these functions interact remains unclear.

In summary, research to-date indicates that there is a piecemeal understanding of project governance and a lack of alignment of definitions and scope, often mixing concepts like factors, mechanisms, enablers without clear distinctions. Some of the confusion around project governance research may have arisen because researchers attempt to merge various governance theories to find a single solution to the problem of project governance. This suggest there is clearly a lack of a shared and universally accepted view of what the functions of project governance are. Therefore, in this paper we present a conceptual framework, structured around the functions of governance that provides suggestions regarding how existing governance theories may best be applied to the context of project governance. Aligned with the aim of the paper, the following research question is addressed: What are the relevant functions for Project Governance?

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FINDINGS AND DISCUSSION

Governance is the action of governing an organization by using and regulating influence to direct and control the actions and affairs of management and others. It is the exclusive responsibility of the ‘governing body’, the person, or group accountable for the performance and conformance of the organization (in a commercial organization, the Board of Directors). The central element of project governance is, therefore, to understand the functions performed by the project governing body.

Current literature does not agree on what constitutes a robust project governance model (Garland 2009). Despite the difference in emphasis, they share the views that project governance is simply concerned with aligning project objectives with an overarching organizational strategy, and that is necessary to create stakeholder value across the organizational network. Garland (2009) proposed four key principles for a good structure of project governance: (1) identify a single point of accountability, (2) ensure a service delivery focus, (3) separate the project and the organization governance structures, and (4) separate stakeholder management and project decision making. Based on these key principles, we conceptualize six functions of project governance (see Figure 1) that must be effectively carried out by a project governing board. They are discussed in detail below.

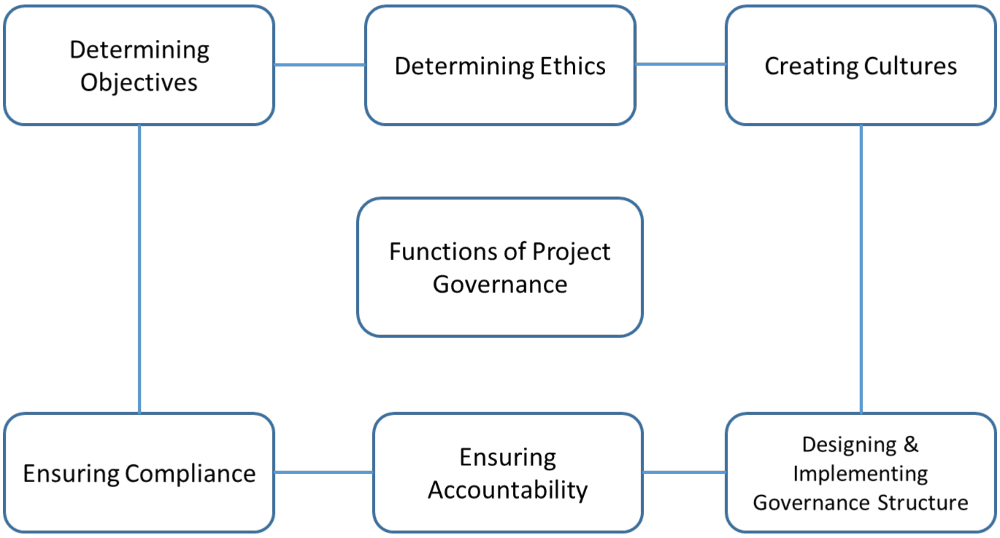

Figure 1 Functions of project Governance

Determining the objectives of the projects

Project-based organisations participate in projects to fulfil their business interests and goals (Artto & Wikström 2005). As such, project goals mostly derive from the wider and more long-term strategic objectives (Swan, Scarbrough & Newell 2010). In this way, the corporate strategy that represents the business interests of the parent organization in the project environment provides the basis for understanding how the project adds value to the organization in the form of outcomes and deliverables

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(Monteiro de Carvalho 2013). All definitions of project governance include setting project objectives and aligning them with an overarching organizational strategy, as an important element (e.g. see Muller 2009; PMI 2013; Turner 2009).

The objectives define the purpose of the project and describe how the purpose will be fulfilled. This function offering strategic management support can take many forms, such as participating in strategic planning and aligning the project portfolio with overarching strategic objectives (Aubry, M. et al. 2011). The objective setting function is a key interface between project management and the governing body:

- The governing body determines the project's objectives;
- There is shared responsibility to develop an effective strategy to achieve the objectives;
- Project management is responsible for implementing the strategy through the efficient and effective use of the organization's limited resources.

In short, the primary purpose of project governance is to ensure that the project will meet the goals and expectations subjected to it by various stakeholders (Ahola et al. 2014). Hence, the core function of project governance is to determine the objectives of the project and to align it to work to deliver the broader strategic goals of the organization.

Determining the project organization ethics

Ethics has developed into an important topic for organizations and their governance (Müller & Lecoeuvre 2014). Ethics are based on morals and values and define the rules or standards governing the conduct of people within the organization. Müller et al., (2013) found that managers of project organizations face different types of ethical issues, and that the way they respond to them can be influenced by the governance structure of the parent organization. The findings suggest that project managers' behaviours differ according to the governance structure.

The ethical standards of any projects are set by the behaviours of people at the top and cascade down the hierarchy. Some common ethical issues confronted the project managers include transparency, optimization, and relationship (Müller & Lecoeuvre 2014), power and political issues, illegal actions, role conflicts. It is pertinent that the project governing body must determine the project ethics within the project governance structure to help project managers dealing with these issues. For example, by adjusting their governance paradigm toward more stakeholder

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orientation, organizations can increase the level of trust between project managers and the key people in the governance structure. Doing this may also enhance trust among other project actors (Müller et al. 2014).

Creating the culture of the project organization

Project organization culture is a subtle process and deals with the way people interact with one another. Culture is conceptualized as consistent, shared by all members, an objective entity, and a cohesive glue for integration processes (Alvesson 2002). It is the environment in which work gets done, and is embedded in the people working for the organization, it naturally evolves as a company grows or changes and requires continuous nurturing and management. Ouchi (1980) connects culture and governance by highlighting the role of a "clan" in the control of organizations. He defines a "clan" as a culturally homogeneous organization that has a shared set of values or objectives together with beliefs about how to coordinate the organization's effort to reach common objectives (Ouchi 1980).

Project performance problems are inevitable result of the organizational complexity, ambiguity, and conflict faced by project actors with diverse and competing project cultures and rationalities (Van Marrewijk et al. 2008). According to Sanderson (2012), even studies of project culture focus too much on facilitating trust and collaboration in the face of uncertainty (Atkinson, Crawford & Ward 2006) and ignore spontaneous micro-processes of governing, which emerge ex post. Turner (2009) argues that governmentality, the willingness of people to 'be governed' and to support the governance system, is at the centre of an effective culture. Hence, project governance becomes the means to acquire order, so that the stakeholders can recognize the common interests among the underlying threats and chances. Other aspects of culture include how supportive the organization is, how innovative, how risk seeking/averse, how open and transparent, how mature and professional, and how tolerant it is. It is pertinent, therefore, for the governing body to determine the culture it wishes to create and influence the operating culture of the organization through the people it appoints to executive positions.

Designing and implementing the project governance structure for the project organization

Having determined the project objectives, the ethics and cultures of the project organizations, a governance structure consisting of shared coordination, control, and safeguarding mechanisms needs to be put in place to align the interests of multiple organizational actors to work

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towards a joint goal (Ahola et al. 2014). To achieve and manage effective cooperation between the key actors and elements, the interdependence between them should be structured and defined (Golden & Martin 2004) in order to realise benefits from intended projects (Zwikael & Smyrk 2015). Likewise, the interdependence between roles, responsibilities and accountabilities should be clarified prior to the start of a project (Ahola et al. 2014; Too & Weaver 2014) so that the cognitive conflicts over the responsibilities and areas of accountability between these roles can be reduced (Forbes & Milliken 1999) and, therefore, project success is improved through the cohesiveness in the governance of the structure.

A central element of good project governance is decision rights (Nault 1998), which are defined as decision-making authority (Dessein 2002). This involves developing a set of relationships among partners, sponsors, contractors, client and other stakeholders (Lu et al. 2015; OECD 2004) and the determination of roles, responsibilities and accountabilities among stakeholders to achieve an ethical, cohesive and transparent decision making process for the sake of achieving the mission of the project organization (Badewi 2015).The key function of project governance body is therefore to propose a project governance structure that combines processes, roles and accountabilities aimed at delivering projects (Biesenthal & Wilden 2014). Good project governance structure can also serve as a mean in which poorly performing projects are highlighted and early warning signs trigger an alert mechanism (Biesenthal & Wilden 2014).

Ensuring accountability by project management

Successful projects contribute to the broader strategic goals on a program or portfolio level of the organization (Williams & Samset 2012). Project management is thus a component of project governance at the project level that deals with the operational control and execution of the daily project work at the project level (Turner 2009). Project governance at the project level has a direct effect on project management and the delivery of project-specific objectives to a broader set of stakeholders (Bredillet 2008). Hence the primary role of project governance is to establish a shared set of rules and procedures that all firms participating to the project are expected to follow (Ahola et al. 2014). In the context of projects, these rules include the definition and regulation of roles, accountabilities, decision making and boundary management (Mosavi 2014).

Joslin and Müller (Joslin & Müller 2015) suggest that project governance has an oversight function which collectively encompasses the project lifecycle to ensure a consistent approach to controlling the project with the aim of ensuring its success. Monitoring and ensuring accountability of project performance is, therefore, a common project governance function

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(e.g. Biesenthal & Wilden 2014; Muller 2009; Too & Weaver 2014; Turner 2006). It has also been argued that the task of monitoring and controlling project to achieve project goals is allocated to decision making bodies who meet on a regular basis to review and make certain decisions including:

- the ethical and cultural environment are maintained within the organization;
- the stewardship and proper use of the resources entrusted to their care; and
- the accomplishment of the strategic plan and fulfilment of the organizations objectives.

The governing body is accountable for the performance of the project organization, and retains overall responsibility for the project organization it governs. However, in most project organisations the governing body cannot undertake all the work of governance itself. To ensure the effective governance of the project organization, various responsibilities need to be delegated to people within the project organization's management (Too & Weaver 2014).

Ensuring compliance by the organization

The aim of project governance is the consistent and predictable delivery of the project's planned contribution to the portfolio and thereby to the achievement of corporate strategic objectives within a corporate governance framework. Following this view, the purpose of project governance is both to define standards or rules that individual projects are expected to comply with, and to monitor the fulfilment of these rules (Ahola et al. 2014). To achieve this, a key function of the project governance board is to ensure the compliance of formal rules (Lusch & Brown 1996). Miller and Lessard (2001) explain that the organizational structure of a project, the shaping of the project, the project's institutional framework and the capacity of self-regulation are essential features of governance. Central to this function is providing relevant stakeholders with:

- assurance of the organization's compliance with its regulatory, statutory and legal obligations;
- monitoring and directing the performance of its management and staff as they work towards achieving the organization's objectives;
- working within the organization's ethical and cultural framework; and
- supporting the values established by the governing body.

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CONCLUSIONS

The growing number of project governance-related papers indicates that project governance is an increasingly important topic. The aim of this paper is to understand the key functions of project governance through a systematic review of project governance literature.

We have found several specific themes and concepts that imply the functions of project governance. The key central functions of project governance identified are: (1) determining the objectives of the project and aligning it to work together towards the broader strategic goals of the organization; (2) determining the project ethics within the governance structure to help project managers dealing with ethics issues; (3) determining the culture it wants and influencing the operating culture of the organization through the people it appoints to executive positions; (4) developing and implementing a project governance structure to realize the benefits from projects; (5) monitoring and ensuring accountability of project performance; and (6) providing relevant stakeholders with assurance of the organization's compliance with its regulatory, statutory and legal obligations.

The proposed conceptual framework describes the key functions that project governance body should carry out to ensure effective governance and hence to ensure value be created from the work and outcomes of projects. Looking ahead and to further validate this framework, we encourage case studies on how project governance functions can be operationalized to create value for organizations. In addition, a large-scale empirical test of how different configurations of functions affect performance in different empirical contexts is encouraged. Furthermore, it is worth investigating the contextual characteristics that govern the suitability of adopting these functions in managing projects.

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MEETING CHANGING INDUSTRY EXPECTATIONS FROM AUSTRALIAN PROPERTY VALUATION GRADUATES

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ABSTRACT

The valuation profession faces significant challenges as more valuation processes become automated, and the role of the valuer becomes more one of data handling than an economic analyst. To respond to industry needs, the role of the valuer must change. It follows that there is a need for universities to re-evaluate their existing property curricula, modifying content where necessary, to prepare their graduates better for a changing workforce. Employing a series of focus group discussions with valuation practitioners, this study examined specific industry expectations and provides recommendations to strategically align Australian property curricula with industry expectations in order to maintain the relevance of property education. The study identified personal, technical and business-related skills that are essential for graduates to possess. The roles of the professional bodies, industry/employers and educators to meet the changing demand on the profession are identified. Changes are required to degree programme content in respect of digital technologies and statistical skills. Whilst the universities offer a curriculum that adheres to the accreditation requirements of the professional bodies, there is also a need to incorporate specialised knowledge with set pathways. The need for students to have practical experience is apparent and undertaking placements with assessment that could be credited as part of the degree is recommended. The study highlights the need for a careful analysis of student learning experience to ensure that graduate skills meet the industry expectations, and that graduates themselves are able to adapt to future changes.

Keywords: Curriculum, Employability skills, Property valuation industry, Tertiary education

INTRODUCTION

It is said that we are on the precipice of great change as a result of digital technologies and many professions globally including law, built environment, construction, property and surveying are endeavouring to comprehend what these changes might mean to their professional bodies

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and also to their members (Susskind and Susskind, 2015; RICS, 2015). In Australia, the valuation profession too faces significant challenges, for example, as more valuation processes become automated, and the role of the Valuer transitions to more one of data handling than economic analysis (Elliot and Warren, 2005; Bradford, 2014). In order to respond to market and industry needs, the role of the Valuer must, inevitably, change (Grover, 2016; RICS, 2016). It follows therefore that education providers such as universities will need to reassess existing property curricula, and to modify them where necessary, in order to prepare their graduates better for a changing work experience. This paper sets out the context and rationale for change, along with the predicted knowledge fields and skills deemed increasingly important to perform well in the future world of the built environment professional.

The research design and approach are described. This qualitative study adopted a series of focus group discussions with valuation practitioners. The research aim is to examine specific industry expectations from valuation graduates and to provide recommendations to strategically align Australian property curricula with industry expectations in order to maintain the relevance of property education. The personal, technical and business-related skills that are essential for graduates to possess are presented in the results and analysis section of the paper. The roles of the professional bodies, industry/employers and educators to meet the changing demand on the profession are identified. In addition the changes required to degree programme content in respect of digital technologies, statistical knowledge and skills are also highlighted. Furthermore, the issue of new, and/or, adapted pathways to membership in the professional bodies is evaluated. Future needs in respect of practical work experience for students are also examined. The conclusion and further study highlights the need for a careful analysis of student learning experience to ensure that graduate skills meet industry expectations, and that graduates are adaptable and flexible in respect of inevitable future changes in the workplace.

LITERATURE REVIEW

The rapid growth in information and communication technology (ICT), coupled with the globalisation of businesses, has provided an explosion of data availability from different sources (RICS, 2016). For instance, digital technologies and artificial intelligence (AI) pose significant threats to the existing valuation practice (Grover, 2016). Many of the steps in the valuation process – data collection, data analysis and data formatting are performed by computerised models and the valuation profession is moving towards automated processes (Grover 2016). In Australia, this is evidenced by companies such as CoreLogic, APM Price Finder and Monitor, all offering computer generated valuation reports, which have been developed to allow for rapid, cost-effective outputs (Weinland, 2016). The computer generated automated valuation models (AVMs) use one or

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more mathematical models, including regression, adaptive estimation, neural networks or an artificial intelligence program, to estimate the value of a property or series of properties (RICS 2016). Unfortunately the conventional valuation methods do not emphasise mathematical and statistical applications (Silva, 2014). Therefore, typical Valuers may struggle with the use of these models and in the future, the mortgage industry will require Valuers who are 'supported by analytics' (Schneider, 2016). Other technology based applications includes blockchain systems for mortgage valuations (Taft, 2016). Blockchain systems contain a list of data records that are organised into a series of blocks, each containing a batch of records of transactions. The benefits for the banking sector to integrate blockchain into their mortgage valuations are the reduced regulatory requirements (Weinland, 2016). Once the database is formulated property purchases can be streamlined with less reliance on mortgage valuations from Valuers. It is envisaged over the next few years, the industry will transform from the art of appraising to the science of appraising (Bradford, 2014). Therefore, the profession must embrace these technological changes as a strategic partner, in other words, as a positive addition rather than a threat (Robson and Downey, 2010).

It is no longer the availability of data and market knowledge that differentiate Valuers (RICS, 2016). It is in fact what they do with the data that differentiates them from their counterparts. Therefore, the role of the valuer is increasingly moving towards being an information analyst from being an information gatherer (RICS, 2016). However it is not only the Valuers who must change, but also the content of educational programs. For instance some skills and knowledge have faded in importance and are declining. Today's professional need to be outcome focused, with good oral and digital communication skills, and posses advanced problem solving skills to deal with complex issues. Because there is no simple solution complex issues are sometimes known as 'WICKED problems' (Bright et al, 2016).

Therefore, advanced problem solving skills should be embedded within educational programmes and, indeed, this approach has been adopted in many surveying, property and engineering disciplines for some decades (Perrenet et al, 2000). Most likely complex problems will involve inter-disciplinary and trans-disciplinary approaches embracing a collaborative methodology (Ashford, 2004). Other skills could also include the ability to evaluate all possible options and to select the best course of action. Concurrently there is also the potential to generate new avenues for value creation from the vast amounts of data now available from real estate (Weinland, 2016). The growth in property trusts and similar investment opportunities have meant that a valuer needs to have a totally different skill-set in order to undertake valuations for these portfolios (Elliott and Warren, 2005). All practicing valuers should be conscious of the changing business environment and the need to strengthen their skills and must be

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forward-thinking to survive in this new era of globalisation (Wilkinson et al, 2016).

Additionally knowledge fields Valuers will need in the future, includes sustainability and how this impacts on value, risk management, upgrading existing skills of data analysis, embracing digital technologies and artificial intelligence (Wilkinson et al, 2017; Elliot and Warren, 2015). With up to four generations now in the workforce, professionals need greater leadership skills to ensure optimum productivity and quality of outputs. Finally professionals, corporations and professional institutions should possess inherent ethical behaviour (RICS, 2016).

Education has a vital role in the way forward and 'the relationship between the professional bodies and universities, government and other stakeholders is, therefore critical if the professions are to emerge as reflective as well as responsive to the issues and expectations of the 21st Century' (Hughes and Hughes, 2013). In this regard the profession faces challenges because of the different criteria to measure the eligibility of Valuers, within the various professional bodies. The need for those organisations to unite behind common standards for education, behaviour, service delivery, monitoring and regulation are emphasised in order to mitigate the risks arising from a lack of a clear identity for the profession as a whole (Thorne, 2012). Employees, in general, and including Valuers, will need to embrace change and become more entrepreneurial, and there is scope and potential for these entrepreneurial skills to be included in education programmes (Susskind and Susskind, 2015). Research predicts that the workforce will have more freelancers or contracted staff who work for multiple employers. This indicates the valuation professions may need to move from honing one particular narrow skill set and develop a broader, adaptable and flexible skill set (Susskind and Susskind, 2015). In some sectors social entrepreneurship and projects involving social good will become increasingly important and redefine employment opportunities and there may be opportunities available for some Valuers.

In conclusion it is the responsibility of the practitioners, professional bodies and educators to embrace changes that market and technological advances bring to the profession and lift the professionalism of the practice so that the valuation industry will continue playing a vital role in the economy.

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RESEARCH METHODOLOGY

Due to the exploratory nature of this research, an inductive qualitative approach was the most appropriate research methodology (Silverman, 2013). Qualitative research has a preference for qualitative data with the analysis of words and images rather than numbers, featuring observation rather than experiment, and semi and unstructured interviews rather than structured interviews. Qualitative research is particularly important when prior insights about the phenomenon under scrutiny are modest (Ghauri and Gronhaug, 2005), which is the case in this study. The need to gather as large a number of views as possible, at a deep and rich level, and; in a short space of time, meant that focus groups were the most cost effective and expedient means of gathering data (Robson, 1993).

The focus groups aimed to canvass as much opinion as possible from the parties most closely involved in the practice of valuation in Australia, i.e. Australian Property Institute (API) members. The API announced the research via an email and newsletter to all members, who were invited to contact the researchers if they wished to participate in the study. Following expressions of interest, participants were invited to attend the focus group sessions hosted at the University of Technology Sydney (UTS) in Sydney, and the Royal Melbourne Institute of Technology (RMIT) in Melbourne and the focus groups were convened over a 2-3 hour period.

DATA ANALYSIS AND INTERPRETATION

Twenty five valuation practitioners participated in the focus group discussions, comprising fifteen individuals in Melbourne and ten in Sydney. They were chosen on the basis of their speciality area in valuation, length and type of experience of valuing different property types, nature of the organisation they worked for and their seniority within the organisation. Within the group of 25 participants, 23 participants each held over 20 years of industry experience. The participants specialised in all areas in valuation including residential, commercial, plant and machinery, agribusiness, asset, going concerns, government, land, retail and leisure, health and care, industrial and logistics, valuation education and specialist property valuations. The majority of the participants were industry experts who were content matter experts within their respective fields and regularly engaged in providing professional valuation services to clients. The participants engaged in the forum discussions in groups comprising between four to five participants, and collectively discussing and listing relevant information.

Focus group participants were asked to identify new knowledge and skills required for the future of the valuation profession and how the current property curricula should be changed to prepare their graduates better for a changing workforce. Table 1 summarises the new knowledge and skills required from future Valuers and what educators can do to ensure these skills are taught to produce ‘job ready’ graduates. The scope was fairly broad and participants covered themes such as educational requirements, specialised knowledge base, technology and the requirement for other industries to be aware of the exact nature and purpose of property valuations.

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Table 1: The role of educators to meet future challenges

New knowledge and skills competency required	Actions for educators
More practical experience before graduation.	• A component of practical experience as part of the degree. • Graduates need to be taught how to do a 'speaking valuation'. • Offer more scholarships for postgraduate students to do research on practical and important issues.
Data / big data analysis.	• Introduce courses on advanced data analysis techniques in valuation.
Practice management & business development skills.	• Offer short training courses.
Specialisation in a few areas of valuation rather than just one area.	• Provide more emphasis on different specialist areas (rural, plant and machinery, business, aged care and retirement living, REITs in teaching
Valuation advice should be beyond just 'point estimates'.	• Need to broaden the scope of valuation by introducing sensitivity analysis, scenario analysis, statistical inferences, risk pricing etc. into valuations
Develop more inter-disciplinary skills.	• Some universities currently limit the scope to meet the needs of the API. Students should learn from other disciplines' problem solving approaches and skills.
Develop greater market forecasting skills and better awareness of property cycles and forecasting trends.	• More emphasis on market analysis and forecasting with the introduction of advanced research skills, market forecasting skills and the use of advanced technology and statistics.
Students should be able to identify the specialist area in property, in which they are interested, earlier in degree programmes.	• Universities go too long without giving students the opportunity to decide if they want to be valuers. Universities should provide sufficient information for students to make career choices earlier in their studies.
Better understanding of local conditions. This is often less understood than valuation theory.	• Increase more focus into local market / context. • Increase focus on work ethics, relevant government codes, standards and regulations.
To be able to provide reality based outputs than models (theory based).	• Get more industry personnel involved and maintain regular contact and dialogue with industry (e.g. guest lectures, industry days, site visits, mentoring, personal counselling and guidance).
Better data collection skills.	• More assessments examining students' research and data collection skills.

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Better data analysis skills.	• Include courses that focus on advanced data analysis techniques related to valuation.
Technical skills.	• Include technology, application of software into valuation teaching (e.g. measuring, sketching, valuations, GIS for mapping and location analysis).
Advisory, communication, team and interpersonal relationship skills.	• Offer public speaking opportunities to students, in the classroom and in formal presentations. • Better training on core business, economic principles, advocacy, marketing and 'people skills'. • Offer short training courses focusing developing personal skills.
Plant and machinery valuations.	• Include plant and machinery courses in to some property degrees, as this is not currently taught in the Australian context.
More emphasis on rural valuations,	• More courses should be offered as there is a great demand for rural valuations.
Consistency in the content covered in property degrees.	• University of Melbourne, RMIT and Deakin offer different courses, course duration and learning outcomes to achieve the same end. Similarly in NSW, UTS and Western Sydney University and Sydney Institute of technology (S.I.T), offer different courses but with similar end qualifications.

(Source: Authors)

Focus group participants consistently identified several important skills necessary for graduates to possess if they were to achieve career success, adding value to the valuation profession. They can be mainly categorised into personal skills (advisory, communication, team, organisational, interpersonal relationship skills), business related skills and technical skills. Recommendations were made that more written and oral requirements should be included in the property curricula and that universities could offer short courses to improve students' personal skills. It was strongly recommended that business skills such as practice management and business development should be included in undergraduate courses. Furthermore participants repeatedly emphasised the necessity of possessing sound technical skills for property graduates and the requirement of including advanced computer skills, data collection and advanced data analysis skills in the curricula and student assessments.

Another major theme emerging is the lack of applied practical skills with the theoretical context delivered at universities. Several participants were of the opinion that new graduates are too focused on employing 'text book' solutions with simplified assumptions to solve problems and lack

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real-world, creative problem solving skills. The need for students to have practical relevant work experience was apparent and the possibility of undertaking placements with some assessment that could be credited as part of the degree, which is a model adopted extensively in other countries such as the UK, is recommended. Whilst the universities should aim to produce more "job ready" graduates, the professional bodies are required to provide assistance with industry involvement. Educators were encouraged to provide more real-world applications, put strong emphasis on case studies as part of the learning, maintain strong industry interaction by utilising their expertise and resources by way of guest lectures, industry days, site visits, mentoring and counselling programmes.

Furthermore, there has been great emphasis on the shortage of skilled knowledge in specialist areas such as plant and machinery, rural, aged care and retirement living valuations and the valuation of large portfolios such as Real Estate Investment Trusts (REITs). The industry perceived that these areas are not sufficiently taught currently and therefore emphasised the importance of including them in the curricula or introducing short courses to cover these emerging specialist areas. In conflict with this skills shortage is the current educational curricula which do not offer clear pathways for graduates to specialise (or to undertake a "sub-major" as part of their undergraduate degree), and the very obvious varying property courses offered nationally, but with the same end result qualification and recognition from the API. The professional bodies need to assist the educational providers to source practitioners with these specialised skills who would be able to help prepare resource notes, guidance with assessment tasks, and undertake lectures as required. In addition, the necessity of broadening the scope of valuation was emphasised and the introduction of alternative valuation products such as broad market analyses, accurate value predictions, and risk pricing into students' learning experience was recommended.

However, these items discussed above cannot be solved in isolation and require a unified approach from both the professional bodies and the educational institutions, and a deeper awareness from industries interlinking with the property professional. Whilst the universities offer a set curriculum that adheres to the accreditation requirements of the professional bodies, there is also the need to incorporate specialised knowledge and skills with set pathways. This would provide a very good defined career approach for the future of the property professional. For this to happen, it is necessary for the professional bodies to forge industry partnerships and provide assistance to the educators. The assistance would include access to resources and skilled people who are able to become involved in the development and delivery of specialised topics, plus opportunities for graduates to obtain practical experience. In conclusion, valuers, professional bodies and educators collectively need to

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advance the professionalism of the valuation practice. In other words, the role of valuers should be changed from simply being 'point in time experts' to a service which the market and clients perceive as adding value to the business process and for which they are prepared to pay a fee worthy of the expertise of the valuation professional.

CONCLUSIONS AND FURTHER RESEARCH

In facing significant challenges including automation of valuation processes, and the role becoming more one of data handling than an economic analyst, the Valuation profession needs to adapt to survive and thrive. In order to prepare new entrants to the profession, universities need to reassess existing property curricula modifying them where necessary, to prepare graduates better for a changing workforce. Using focus groups with valuation practitioners, this study examined industry expectations from valuation graduates and identified steps to strategically align Australian property curricula with industry expectations to ensure education remains relevant.

The research identified personal, technical and business-related skills deemed essential for graduates. The respective roles of the stakeholders; professional bodies, industry, employers and educators to meet the changing demands are evaluated. Changes are needed to degree programme content in respect of digital technologies and statistical knowledge and skills. Whilst the universities offer a curriculum that aligns with professional body accreditation requirements, there is a need to incorporate specialised knowledge and skills. Students need practical experience and undertaking industry placements with assessment that is credited as part of the degree is recommended; the UK sandwich degree model. The study highlights the need for a careful analysis of student learning experience to ensure that graduate skills continue meet evolving industry expectations and that graduates are flexible and adaptable to inevitable future changes.

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A METHOD TO MEASURE THE SIZE OF THE AUSTRALIAN BUILT ENVIRONMENT SECTOR

ABSTRACT

The building and construction industry, at around 7 percent of Australian gross domestic product, has an important role linking suppliers of materials, machinery, products, finance, and professional and technical services. These two views have been called broad and narrow, with the narrow industry defined as on-site activities of contractors and subcontractors and the broad industry as the supply chain of materials, products and assemblies, and services. The term that arguably best describes the broad industry is the built environment sector. One method that can be used to estimate the contribution of the built environment sector to the economy is through preparation of a satellite account, which reclassifies expenditures available in different industry groupings into a single sector. The *System of National Accounts* published by the United Nations explains how these are used to provide more detail on sectors that are not adequately represented in the national accounts and gives examples. This paper details how a satellite account for the Australian built environment sector can be compiled from ABS industry data. The paper identifies the sources of the data required and the stages involved in the process of developing a satellite account. Tables at the three and four digit ANZSIC level are presented as examples of what key elements of a satellite account would include.

Keywords: broad construction industry, national accounts, industry data, satellite account

INTRODUCTION

The idea that the construction industry as measured in the national accounts, using the standard industrial classification (SIC) of industries, is only one part of the creation and maintenance of the built environment and the range of industries that encompasses is not new. Turin (1969) and the Bartlett International Summer School series in the 1980s

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advocated looking at the sector that produces the built environment in broad and integrative terms. Recognition of the industry's extensive linkages with other sectors, and its impact on other parts of the economy as much greater than the direct contribution of construction activities, which are typically measured through the industry's high multiplier effects (Lean 2001, Gregori and Pietroforte 2015), gives the industry an important macroeconomic role (Lewis 2009, and Meikle and Gruneberg 2015).

The SIC version of the construction industry captures the on-site activities of contractors and subcontractors. However, the construction industry links suppliers of materials, machinery, products, services, and other inputs into the built environment. In Pearce (2003) these were called the broad and narrow industry structures. The narrow industry was defined as the on-site work reported as industry output in the national accounts, and the wider industry as "the supply chain for construction materials, products and assemblies, and professional services such as management, architecture, engineering design and surveying" (Pearce 2003:10).

Research has focused on the definitional aspect of this wider construction industry. Pearce (2003) went through the SIC definitions of industry groups and classes in order to identify the backwards and forwards linkages that are relevant to the on-site work done by the construction industry, which is the narrow definition. Similarly, Squicciarini and Asikainen (2009) is a thorough comparison of the European and North American SIC classes that can be included in a wider definition. They concluded measures of composition, structure, value added, skills, and R&D input and output of the construction sector change substantially when a broader definition of the sector is used. In Squicciarini and Asikainen the definitions are built around preproduction activities and services, core production and postproduction activities and services in what the authors called a value chain approach to the industry.

There have been attempts to estimate the economic contribution of the wider construction industry. Using what they called a 'meso-economic' approach (i.e. between micro and macroeconomics) Carassus et al. (2006) compared the size of the 'construction sector system' in seven countries, again using a very wide definition to include property management, repair and maintenance and the institutional actors involved. (Because the necessary data is not available for all the activities included these estimates are somewhat speculative for some countries.) Ruddock and Ruddock (2009) also estimated the size of the construction sector for 20 European countries, which ranged between 12 and 22 per cent, with an average of about 17 per cent.

There have, however, been only three studies that have quantified the relationship between the narrow and wider definitions of construction. Of

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these three previous studies two were for the UK, done by Ive and Gruneberg (2000) and Pearce (2003), and one for Australia by de Valence (2001) based on an earlier study (AEGIS 1998). The relevant data from these studies is reviewed in the following section, followed by a discussion on the importance of measuring the wider industry. How this could be done using SIC data by preparing satellite accounts from the SIC data in the national accounts is also discussed, concluding with an argument for using the term 'built environment sector' for the wider definition of construction.

PREVIOUS STUDIES

Ive and Gruneberg (2000) used a stages of production approach, with the construction industry one part of the process of producing and maintaining the built environment. They were the first to argue "A *narrow* definition of the construction industry includes only those firms undertaking on-site activity" (2000: 9) whereas a *broad* definition includes many firms from other industries involved in production of the built environment (their italics). They then went through the SIC classification to identify the other industries involved at the four digit SIC group level (which were listed in Table 1A, pages 25-28). From this they estimated the output and employment of firms directly and indirectly involved, shown in Table 1, finding "over 11.2 per cent of employees in employment are engaged in production of the built environment. This compares with the figure of 4.7 per cent taking the construction category alone." (2000: 11).

Table 1. UK data for 1993

Industry	Output % going to construction	Employment	Labour equivalent engaged on construction related output
Agriculture	0.02	281,00	66
Energy	1.65	443,000	7,302
Manufacturing	13.12	5,012,000	657,805
Construction	100.00	1,060,000	1,060,000
Distribution	10.43	3,551,000	370,372
Transport	2.09	925,000	19,298
Business services	6.77	3,135,000	212,312
Other services	2.50	6,748,000	168,437
Other sectors	0.0	1,198,000	0
Total		22,353,000	2,495,592

Source: Ive and Gruneberg (2000: 12)

This research was the basis of the industry estimates given in Pearce (2003), which adopted the narrow and wide terminology of Ive and Gruneberg. The report also used the four digit SIC industries identified by

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Ive and Gruneberg to quantify the relationship between the narrow and broad definitions of the construction industry by including the contribution of related industries. Pearce found, for the UK in 2001, the number of firms and the value added in five industry groups, shown in Table 2. In both cases contractors account for around half the total.

Table 2. UK shares of value added 2003

Industry	No. of firms	Share of value added
Contractors	192,404	52%
Mining and quarrying of construction materials	2,248	2%
Manufacture of construction products	20,863	15%
Sale of construction products	81,997	15%
Professional services	57,636	16%

Source: Pearce (2003: 13-15).

The Statistical Appendix, in Table 16, then took three and four digit industry SIC data and, broadly, got the same result for five measures. Table 3 shows this data from the 26 three and four digit classes and groups identified as relevant, aggregated into their parent SIC industry sectors. Ruddock and Ruddock (2009) also took this approach to SIC data, and built on it to get their estimates for the construction sector in 20 European countries, however they did not include the relative share of construction output in the total in their data.

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Table 3. UK data for construction and related industries

SIC	Industry	Turnover	GVA at basic prices	Employm ent costs	Employment during year
F	Construction	131,179	47,647	23,798	1,370,000
C	Quarrying	4,439	1,642	695	29,000
D	Manufacturing	40,948	15,265	9,044	465,000
G	Trade	24,228	5,135	3,019	155,000
K	Real estate, renting and business activities	30,207	16,814	9,247	399,000
	Total	231,001	86,503	45,803	2,418,000

Source: Pearce (2003: 73-74).

The data set in Pearce is unusually detailed, and demonstrates how intensive the process of extracting data at this level of detail is. Note that both Ive and Gruneberg and Pearce used the 2003 UK SIC, which has since been revised as the UK 2007 SIC. Taking the data in Table 3 and using it to find the percentage of construction in the total gives Table 4.

Table 4. UK percentage shares of total output

SIC	Industry	Turnove r	GVA at basic prices	Employmen t costs	Employment during year
F	Construction	57	55	52	57
C	Quarrying	2	2	2	1
D	Manufacturing	18	18	20	19
G	Trade	10	6	7	6
K	Real estate, renting and business activities	13	19	20	17
	Total (percentage)	100	100	100	100

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In a similar analysis of the Australian industry, de Valence (2001) compared the size and scope of construction, firstly using data from the construction industry survey done by the Australian Bureau of Statistics (ABS 1998), and secondly from an industry cluster perspective. The cluster analysis approach was used by the Australian Expert Group on Industry Studies (AEGIS 1999) to include SIC industry sectors that provide services before and after construction in an approach that focused on the linkages and interdependencies between firms in a chain of production.

AEGIS divided industries into five product-system segments: on-site services; client services; building and construction project firms; building products and supplies; and building fasteners, tools, machinery and equipment manufacturing. Each of these was then subdivided into four product/service classes based on SIC data from the ABS. The AEGIS data for 1997 is shown in Table 5. When the data from both sources was compared, the size of the industry almost doubles, both in total income (and therefore share of GDP) and employment. The ABS industry survey income for 1996 was $58.6 billion, compared with total income of $110.4 billion from AEGIS, and total employment increased from 484,100 to 682,000.

Table 5. Australian industry data

Industry Segment	Total Industry Income $m	Employment
On-site services (trade services)	21,898	220,000
Building and construction project firms	34,250	108,000
Client services (engineering, technical, etc.)	8,607	102,000
Materials and product supplies	41,352	222,000
Machinery and equipment supplies	4,312	30,000
Total	110,419	682,000

Source: de Valence (2001).

When the industry segment shares in Table 4 are converted to percentages, with the On-site services and Project firms added together to make the site-based measure of construction, the results look similar to the UK data in Table above. In this case the narrow industry is 51 per cent of income and 48 per cent of employment in the broad industry.

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Table 6. Australian percentage shares of total output

Industry Segment	Total Industry Income	Employment
On-site services (trade services)	20	32
Building and construction project firms	31	16
Client services (engineering, technical, etc.)	8	15
Materials and product supplies	37	33
Machinery and equipment supplies	4	4
Total (percentage)	100	100

MEASURING THE WIDER INDUSTRY

While it would be preferable to have regular, detailed data on the size and scope of the wider construction industry/sector/system, at present that is not available. Therefore, a general rule of thumb is an alternative approach. Based on the studies above it would be reasonable to conclude the wider construction industry is around twice the size of the narrow industry. Note this is not an accurate measure of the wider industry, but a rough and ready estimate of its approximate scope and size. While this rule needs to be tested, it is likely to apply across many or most countries most of the time.

This rule is a useful yardstick for four reasons:

1. It does not have to be exact to convey the importance of the wider construction industry to the economy;
2. It is based on regular and readily available data on (the narrow definition of) construction industry output, thus avoiding the infrequent nature of the input-output data used to calculate multipliers and study industry linkages;
3. It naturally varies over time with fluctuations in both the business cycle and the building cycle, emphasising the macroeconomic importance of the industry; and
4. It is not sensitive to local conditions, in that the share of the different industries included in the total will vary across countries, and the output shares of residential and non-residential building and engineering construction will vary over time, but the cumulative contribution of these industries to economic activity can still be estimated.

There is a way to turn this rough estimate into a more credible measure, and that would be through the preparation of what is known as a satellite account, which reclassifies expenditures usually presented in different industry groupings into a single sector. These are used to provide more detail on sectors that are not adequately represented in the national accounts. The *System of National Accounts* published by the UN (2008),

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which provides guidelines for national statistical agencies, in Chapter 29 explains the reasons for preparation of satellite accounts gives examples of their presentation. The process is similar to that used in Pearce (2003) where SIC data across industries is aggregated, but is done at a higher level of detail using the supply and use data from the national accounts.

At this time the most widely found satellite account is for tourism (nine countries, all irregular, often jointly funded by industry and users), but they have been produced or proposed for a range of other industries such as health, the environment, R&D, information technology, infrastructure, non-profit institutions, human capital and households. While these are not produced annually, and are sometimes not feasible at high levels of disaggregation, they allow re-use of existing data and thus maximise its usefulness. With the funding restrictions facing statistical agencies it would be important to focus on the most important contributors to the construction industry. A version of satellite accounts known as key sector accounts selects a group of products or industries that are economically important and aggregates their data, and that could be tried as another approach.

The construction industry can be depicted in a variety of ways, but emphasising how the built environment is created through the project initiation, design, fabrication and construction process is the most representative of the whole industry. The complexity and number of activities involved in the built environment has, to date, prevented a coherent view of the industry developing. In turn, this has made efforts to improve the performance of the industry largely ineffectual. As Meikle and Gruneberg conclude in their analysis of international construction data:

> Because of the issues and difficulties … construction activity data – national and international – can be misinformed and misreported. Governmental statistical agencies and industry commentators require improvements in the official definitions of construction and the way data is presented. There is a need for better information on the various measures of construction activity. (2015: 127).

THE BUILT ENVIRONMENT SECTOR

The construction industry can be depicted in a variety of ways, but emphasising how the built environment is created and maintained through project initiation, design, fabrication and construction to operation, repair and maintenance is the most representative of the built environment sector as a whole. The complexity and number of activities involved in the built environment has, to date, prevented a coherent view of the industry developing. In turn, this has made efforts to improve the performance of the industry largely ineffectual.

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Part of the problem here may be that the same term, 'construction', has been used in a number of different definitional and scope studies. As the discussion above shows, it has a range of definitions and has been given widely different scope in different studies. Thus Ive and Gruneberg (2000) had a 'construction sector' and Pearce (2003) described his approach as contrasting 'narrow' and 'broad' views of the industry. In Squicciarini and Asikainen (2009) the definitions are built around 'narrow' and 'wide' approaches, and like Ruddock and Ruddock (2009), built on the Pearce report approach with a 'construction sector'. Carassus (1998) had a 'construction system', and de Valence (2001) and Carassus et al. (2006) an industry 'cluster'. It would be helpful to agree on a common usage.

The term that arguably best encompasses the extraordinarily large number and range of participants in the creation and maintenance of the built environment, from suppliers to end users, is the built environment sector (BES). This would also be the obvious choice of a name for a set of satellite accounts. The special role for construction economics here is in the definition and measurement of the BES, which is essential for tracking its development, characteristics and performance.

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AN EVIDENCE-BASED INTERPERSONAL COMPETENCY ASSESSMENT FRAMEWORK (I-CAF) FOR CONSTRUCTION

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ABSTRACT

Communication, conflict management, cultural awareness, leadership, motivation and team working skills are main interpersonal competencies that students at construction management discipline need to build up during their studies at University. It has recently been shown that augmenting students' interpersonal competencies prepare graduates to embrace the novel opportunities and challenges they are facing in the industry. This paper aims to develop a framework to evaluate students' current interpersonal and socio-cultural competencies in the Bachelor of Construction Management and Property (BCMP) Program at the University of New South Wales by addressing the main research question of "What is the deviation of the current level of interpersonal competencies from the targeted level of competencies in BCMP Program?" Two different cohorts of students from the first- and final-year of BCMP program were selected in this study to prevent biases potentially leading to false positives in the data collection phase. A structured questionnaire survey was used for data collection. The results show that first-year students' interpersonal competencies are far behind final-year students. This is because students strongly agreed that their industry experience had helped them to improve their interpersonal skills. First-year students were not able to provide enough evidence for their interpersonal competencies; however, final-year students had provided robust evidence to support their level of the competencies. The identified gaps could be used as guidelines in the development of teaching and learning activities in curriculum design.

Keywords: Construction education, interpersonal competencies, student experience.

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INTRODUCTION

Traditional educational systems have been criticised for many years. Higher education claim that students can improve their competencies during their studies in the universities, however, many other studies showed that students' competencies had been improved by working and studying simultaneously. Combining both studies and work can help students to enhance their competencies (Schunk, 1991). Competency refers to the qualities and characteristics that individuals possess (Spencer, 1997; Spencer & Spencer, 1993). It consists of knowledge, skills and professional attitude. Competency can be assessed and it can be improved via professional education and structured development. Jaafari (2006) suggested that students' competency in each element can be assessed in terms of their knowledge, abilities to perform and the respective professional attitude, using a scale ranging from "aware" (lowest level) to "transformative" (highest level). Students need to acquire several types of competencies. These competencies range from technical (or base discipline) competencies (e.g., construction management); management competencies (e.g., project-based management and general management) and interpersonal competencies (sometimes referred to as leadership and soft competencies. Dimensions of professionalism include (1) knowledge, (2) professional skills, (3) creativity, (4) ethics and leadership, (5) research skills, (6) social responsibility, (7) sustainable career (Lee, 2014).

In project management, competence is the demonstrated ability to perform activities within a project environment that lead to expected outcomes based on defined and accepted standards (Crawford, 1997). She referred interpersonal competencies to those behaviours, attitudes, and core personality characteristics that contribute to a person's ability to manage projects. Jaafari (2006) classified students' technical and interpersonal competencies in project management field in five levels including; aware, informed, involved, competent, transformative. Students understand the theory and have willing to learn in aware level. In the informed level, they use experience and professional judgment as a guide to planning and action. They also can identify knowable unknowns and guides effort towards the results. In the involved level, students have the ability to contextualise knowledge, and they can use expertise to revise goals plans and actions. In the competent level, students have established feedback and optimised the application of theory in the case of a problem, they take a holistic systems approach to problems, goals and plans. They manage new situations, and challenges beyond expectations and they have the ability to manage large endeavours and systems with great complexity. Finally, in transformative level, students have innovation focus to improve orextend application areas, they have strategic planning and leadership of large complex systems, they take novel approaches to complex problems; synthesis mindset, they foster creativity, inspiring peers and teams in terms of strategy and people and

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they have ability to unlock value creation potential & inspire peers and teams to achieve.

Another school of thought recently developed by Bigelow et al. (2015) to evaluate the depth of skills and competencies for construction degree graduates. They evaluated depth of understanding of students and graduates in construction programs on a four-level basis (i.e., awareness, comprehension, application, and analysis). In awareness level, the simplest level, the graduate is aware of the skill and its meaning. In comprehension level, the graduate understands the skill, but is not yet able to apply it. In application level, the graduate can implement the skill. In analysis level, the highest level, the graduate can not only apply a skill, but also able to analyse and understand it completely. Previous studies have been conducted to determine the skills the construction management graduates need to possess for entry level positions in the construction industry (Ahn et al., 2005 and Bigelow et al., 2015). Most of these studies reported that interpersonal skills and technical expertise as the main qualities graduates should have upon entering the industry. However, far too little attention has been paid to the depth of understanding in those skills in different years of studies. In addition, no research has examined whether studying and working simultaneously can enhance students' interpersonal competencies or not. The objective of this research is to develop a framework to evaluate students' current interpersonal competencies in the Bachelor of Construction Management and Property (BCMP) Program at the University of New South Wales.

INTERPERSONAL COMPETENCY ASSESSMENT FRAMEWORK

Table 1 shows the proposed Interpersonal Competency Assessment Framework (I-CAF). I-CAF encompasses six interpersonal competencies at five assessment levels via three steps. I-CAF is evidence-based framework and students need to provide evidence from the construction industry, or casual work or their group assignment work to support the level of their competencies. The evaluation criteria for each individual competencies are examined next.

Table 1 Interpersonal Competency Assessment Framework (I-CAF)

Interpersonal Competencies	**Levels**	**Steps**	**Types of Evidence**
IC1) Communication IC2) Conflict Management IC3) Leadership IC4) Cultural Awareness IC5) Team Working IC6) Motivation	L1) Awareness L2) Comprehension L3) Involvement L4) Analysis L5) Reflectiveness	S1) Basic S2) Intermediate S3) Advanced	T1) Construction industry T2) Casual work T3) Group assignment

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IC 1: Communication

Communication has been identified as one of the single biggest reasons for students' success and failure in their group assignment tasks, and for graduates to work in construction industry (Dunbar et al., 2006). Effective communication within team members in completing the group assignment tasks is very essential. Students have to use proper communication tools for their group assignment tasks (e.g., Moodle, student email, meeting room, WIKI, Facebook Messenger, Google drive). They also need to manage to identify information required for group assignment tasks. Students need to show their abilities to present thoughts and information confidently either in written or oral format. Finally, it is imperative students to provide feedback to their peers in completing the group assignment tasks (Macht et al., 2013 and PMI, 2016).

IC 2: Conflict management

Conflict is inevitable in a team for completing group assignments. Students must to identify the causes of conflict and then actively manage the conflict thus minimising potential negative impacts. Students need to establish a collaborative approach among the group members to complete their group assignment tasks, and to analyse and handle conflict among team members. Negotiation plays an important role among group members in resolving disagreements. Students need to learn how to respond calmly and appropriately when dealing with conflicts and how to pay attention to the feelings of parties involved in the conflict. Finally, they must enhance their abilities to create new options and perspectives in conflict resolution (Ahn et al., 2005 and PMI, 2016).

IC3: Leadership

Leadership involves focusing the efforts of a group of students toward a common goal and enabling them to complete group assignment tasks in an efficient way. It is about the ability to establish and maintain group vision, and ability to evaluate the group performance. Setting up goals, standards, rules and regulations play crucial roles in students' team success. Students need to assign a leader in their team because the leader can integrate individual demands, requirements, commitments and limitations into decisions that will affect overall group performance (Zhang et al., 2013).

IC4: Cultural awareness

Students work in a team environment of cultural diversity. By understanding and capitalising on cultural differences, students are more likely to create an environment of mutual trust and a win-win atmosphere. Students must be aware of, understand and appreciate and respect personal and cultural differences. They need to enhance their abilities to build a good relationship with the diverse group and communicate in a respectful manner (PMI, 2016).

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IC 5: Team working

Team working is the process of helping a group of students to work with each other, the leader, the tutors and lecturers and the university. Students are to oversee group processes through consensus building and coordination (e.g., set goals for assignment tasks, an overall understanding of assignment tasks (project description), distribute group assignment tasks into smaller tasks to each team members, find the problems during working and solve it together). Students must show their abilities to allocate work tasks to team members effectively and to set and attend scheduled meetings. It is very essential for students to demonstrate their abilities to work independently or as part of a team (Conrad and Sireli, 2005).

IC6: Motivation

The overall success of the student group assignment tasks depends heavily on the team members' commitment, which is directly related to their levels of motivation. Students need to create a learning and working environment to meet group assignment tasks' goals while satisfying individual team members' needs related to what they value most. For motivating each other, students need to understand and analyse individual team members' strengths and weaknesses. In addition, the ability to provide recognition to individual group members is important to enhance the motivation in the group (PMI, 2016).

RESEARCH DESIGN

A survey questionnaire was distributed to two different cohorts of students in the BCMP program to prevent biases potentially leading to false positives in the data collection phase. They were first-year students enrolled in Construction Project Management Theory course and final-year students enrolled in Construction Project Management Practice Capstone course. Using a Likert scale 1 to 5 (1= very low, 2 = low, 3 = medium, 4 = high and 5= very high), the survey respondents were asked to evaluate their competencies in communication, team working, conflict management, leadership, cultural awareness and motivation based on a set of 41 questions. They were required to provide evidence for their interpersonal competecies in completing their group assignment tasks. Finally, they were asked to what extent their industry experience had helped them to improve their interpersonal competencies. The numbers of responses received were 162 and 31 for the first- and final-year students, respectively. The corresponding response rates are 86% and 100%. The survey respondents' profile is illustrated in Table 2. It can be seen that about 60% of the first-year students have working experience in the construction industry. In contrast, almost all (93%) the final-year students have working experience in the construction industry.

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Table 2 The survey respondents' profiles

	1st year	Final year
Employment history	**162**	**31**
Full-time employment	36	18
Part-time employment	60	11
Unemployed	66	2
Construction industry experience	**162**	**31**
0 year	66	2
<1 year	62	8
1-2 years	19	13
2-5 years	9	8
>5 years	6	0

RESULTS AND DISCUSSIONS

Table 3 presents a summary of the grand mean for students' interpersonal competencies based on proposed interpersonal competency assessment framework (i-CAF). With the exception of Cultural Awareness competency, a two sample t-test results show that there is statistically significant difference between the first-year and final-year students for the other five competencies. Interestingly, there is a significant gap between first-year (mean = 3.38) and final-year students (mean = 4.40) in Communication competency. Interestingly, in their responses to a question on "Ability to establish a collaborative approach among the group members to complete the group assignment tasks", it was found that the first-year students can manage conflicts better than final-year students, and they were more motivated in completing the group assignment tasks. On the other hand, final-year students' Leadership and Team Working competencies are far better than first-year students. In overall, both groups of students are competent in Cultural Awareness in compare with other competencies in managing their group assignment tasks.

Table 3 Interpersonal Competency Assessment analysis

Interpersonal Competencies	All		First-year		Final-year		t-value	Sig (2-tailed)
	Mean	SD	Mean	SD	Mean	SD		
Communication	3.89	1.90	3.38	1.59	4.40	2.21	2.55	0.038
Conflict Management	4.40	2.30	4.50	2.65	4.31	1.95	1.87	0.051
Leadership	4.05	2.00	3.76	1.85	4.27	2.15	1.95	0.040
Cultural Awareness	4.72	2.59	4.71	2.62	4.73	2.57	1.43	0.089
Team Working	4.28	1.57	3.92	1.50	4.65	1.65	2.41	0.046
Motivation	4.16	2.06	4.22	2.11	4.10	2.01	1.68	0.055

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Corresponding to the 5-point Likert scale of very low to very high, their interpersonal competencies were categorized into five levels, namely: Awareness (1), Comprehension (2), Involvement (3), Analysis (4) and Reflectiveness (5). Table 4 presents students' level of competencies based on proposed I-CAF in five levels for the two cohorts of students. It can be seen that first-year students' competencies have been more at level 3 or Involvement level. In other words, they have been aware and have comprehended the interpersonal competencies thoroughly and they are involvement. First-year students showed less analytical and reflective skills in their interpersonal competencies in completing the group assignment tasks. However, final-year students have claimed with evidence that they are aware, comprehended, involved completely in their interpersonal competencies and they are more than first-year students in analysis and reflectiveness levels.

Table 4 I-CAF and level of competencies

Competecny Levels	**Awareness n, (%)**		**Comprehension n, (%)**		**Involvement n, (%)**		**Analysis n, (%)**		**Reflectiveness n, (%)**	
Interpersonal Competencies	**1st yr**	**Final yr**	**1st yr**	**Final yr**	**1st yr**	**Final yr**	**1st yr**	**Final yr**	**1st yr**	**Final yr**
Communication	0	0	15 (9%)	5 (16%)	85 (52%)	5 (16%)	30 (19%)	9 (29%)	32 (20%)	12 (39%)
Conflict Management	5 (3%)	0	24 (15%)	2 (6%)	51 (31%)	8 (26%)	29 (18%)	10 (32%)	53 (33%)	11 (35%)
Leadership	4 (2%)	0	37 (23%)	1 (3%)	48 (30%)	9 (29%)	40 (25%)	6 (19%)	33 (20%)	5 (16%)
Cultural Awareness	0	0	0	0	44 (27%)	8 (26%)	51 (31%)	8 (26%)	67 (41%)	15 (48%)
Team Working	8 (5%)	0	22 (14%)	1 (3%)	42 (26%)	7 (23%)	49 (30%)	12 (39%)	41 (25%)	11 (35%)
Motivation	3 (2%)	2 (6%)	24 (15%)	5 (16%)	56 (35%)	7 (23%)	40 (25%)	8 (26%)	39 (24%)	9 (29%)

Figure 1 shows first-year students' assessment of their interpersonal competencies. Most of the first-year students are in the Involvement level in communication, leadership and motivation competencies. However, they are more reflective in conflict management and cultural awareness. A high number of first-Year students claimed that they are in analysis level in team working competency.

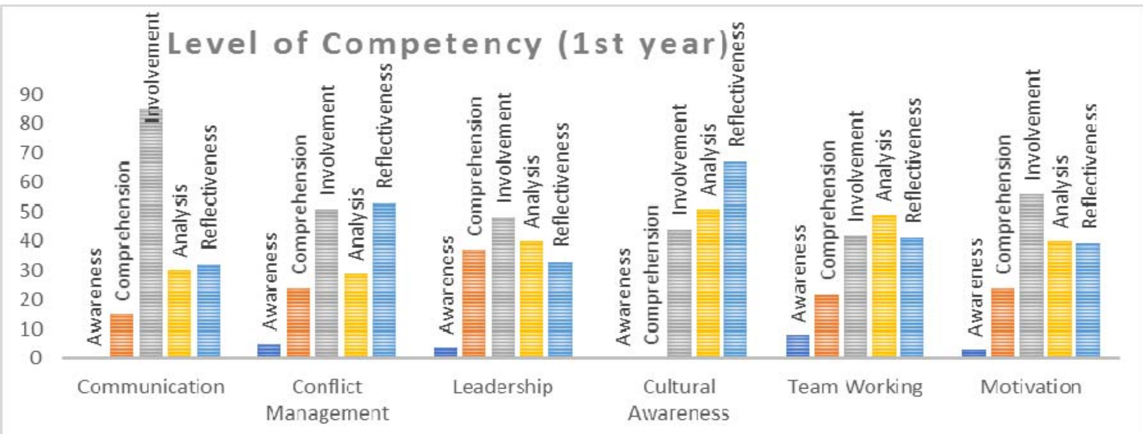

Figure 1 Interpersonal competencies and competency levels (first-year students

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Figure 2 shows final-year students' assessment of their interpersonal competencies. Most of the final-year students are in reflectiveness level in communication, conflict management, cultural awareness and motivation skills. However, their leadership skills are not in reflectiveness level, and they are far behind in involvement level as compared to first-year students. A large group of final-year students claimed that they are in analysis level in team working competency which is similar to first-year students' claims.

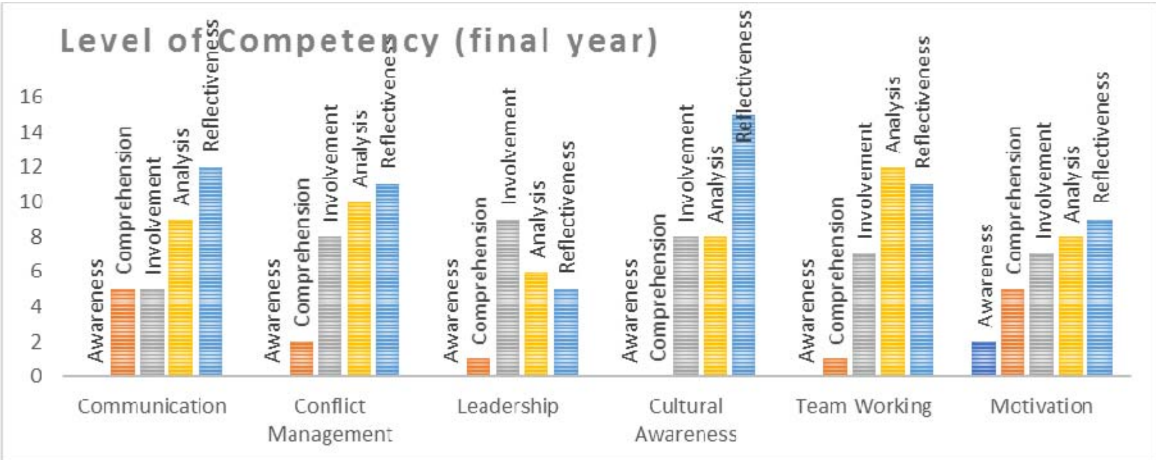

Figure 2 Interpersonal competencies and competency levels (final-year students)

CONCLUSION

I-CAF can help to identify the gaps in students' interpersonal competencies in construction education. It is a useful tool for assessment of factors and developing teaching and learning strategies that can help students to improve their interpersonal competencies. The I-CAF outputs can serve as a reference point for students in construction management education as they develop more interpersonal competencies, set targets and make improvements over time. It also integrates students' interpersonal competencies with graduate attributes of an institution, reflecting the need to improve their weaknesses that pave the way for their sustainable career development in the industry.

In addition, I-CAF can be amalgamated with other competencies such as technical and contextualised competencies and aligned with graduate attributes. This would be an innovative teaching and learning initiative which integrates I-CAF with Moodle or Blackboard for evidence-based competency assessment. Students can start working with this module from the first semester and set some targets for their interpersonal and technical competencies and track their continuous improvement over semesters. The results also would be instrumental for a teaching and learning assessment.

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This study presented empirical evidence that contributes to knowledge about improving students' learning and teaching experience in construction education, but these research findings must be interpreted within the limitations of this study, which is exploratory in nature. Interpersonal competencies and skills limited to six major ones in this study, however, other sociocultural competencies such as innovation, creativity and entrepreneurship were not analysed. In addition, learning and teaching theories should have been used to support the I-CAF. However, more research on development of I-CAF topic needs to be undertaken before the association between students' interpersonal skills and students' experience is more clearly understood. Further research should be done to investigate the correlation of each individual factors with the respective interpersonal skill constructs. A further study with more focus on significant factors in each interpersonal skill is therefore suggested and finally further research might explore the relationship between I-CAF and learning and development planning for construction education.

ACKNOWLEDGMENT

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PROFITABILITY OF LARGE COMMERCIAL CONSTRUCTION COMPANIES IN AUSTRALIA

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ABSTRACT

Increased competitiveness in the Australian building and construction industry has led to reduced profits for builders particularly for tier 1 builders offering essentially undifferentiated offerings. An analysis of the profitability of a sample of large commercial builders based in Victoria have confirmed that net profit margins for these companies are 2 and 3 percentage points of total revenues – wafer thin. The aims of this paper are to characterise the profitability of these commercial builders by examining a range of profitability measures, and to investigate this loss of value across the construction supply chain. The findings indicate that the average net profit margin has nearly halved from 3.2% in 2006 to 1.7% in 2015. Companies with large revenues, those exceeding $500 million annually, exhibit a generally lower profitability than smaller companies. Despite this lower profitability, return for shareholders remains reasonable with an average return on equity of 20% reflecting a shift to higher leverage, lower risk, asset light business model. Like all businesses, construction companies must demonstrate their financial viability by turning a profit and providing a convincing risk-adjusted return to their investors. Empirical evidence suggests that companies reporting low profitability are at increased risk of insolvency. Failure to acknowledge this may lead to serious financial implications for the industry and the economy.

Keywords: commercial builders, profitability, competitiveness

INTRODUCTION

The recent IBISWorld Industry Report for Commercial and Industrial Building Construction in Australia (Kelly, 2016), presents an optimistic outlook for the Australian construction sector. It states: *"The industry's solid performance over the past five years has supported the gradual widening of profit margins."* (p. 5). The years 2010-11 saw a significant cyclical downturn in the economy, which impacted the construction

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sector. The intervening period of economic rebound provided opportunities for recovery as construction firms met latent demand for warehousing, transport infrastructure, commercial space, hotels, and industrial expansion. Annualized revenue growth over the last five years is estimated at 3.5%, and the trend is projected to continue.

There is, however, cause for scepticism. The construction industry is mature, and as such cannot expect sustained growth beyond that of the overall economy. Australia's annualized GDP growth rate, through to 2021, is projected at only 2.6%. Moreover, since the industry is predominantly populated by small firms, with only 3% employing more than 20 people, entry barriers are low and competitive intensity is high. Compounding this dynamic, the construction industry has seen year on year increases in the number of active participants. These factors, combined with limited opportunities for off-shore expansion, modest technological developments in efficiency, and increasing costs, can be expected to put downward pressure on profits and ultimately to thin out the industry into a smaller number of competitors.

Currently, the yield on Australian Government ten-year bonds is 2.5%, with bank deposits paying 2.4%. Given the substantial risks associated with construction, should profit rates approach these levels the incentive to remain in the market would be marginal. While exiting the market is easier for small operators, exit costs for large firms with substantial capital assets are high. A ubiquitous strategy employed by firms subject to high market exit costs in a declining profit environment, is to endure losses for as long as possible, while waiting for the industry to return to profitability. Profitability returns as players are culled through bankruptcy or acquisition, and competitor concentration is reduced.

While IBIS reports revenue growth for the largest construction companies at between 7 to 10%, Deloitte claims profit margins can be as low 0.3%. (Deloitte, 2016) The labour costs for Victorian firms are the highest, and it is the larger Victorian construction firms that may be experiencing the greatest erosion of profits. A sustained industry-wide reduction in risk-adjusted profit levels would portend a looming rationalization of the industry. This study sets out to quantify the profitability of large Victorian based construction companies, and describe trends in profitability over time.

Literature Review

Previous research on company profitability where profitability and other financial ratios were utilised for managerial analysis can be found in a review by Horrigan (1968). Beaver (1966), and later Altman (1968), suggested statistical models that were based on financial ratios to predict the risk of company failures. One of the earliest studies on the construction sector was carried out by Fadel (1977) for UK enterprises indicating that companies with larger revenues were more profitable. In a

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similar vein, Akintoye and Skitmore (1991) found that the profitability of UK general contractors was positively correlated with company size.

The shortcomings of profitability or ratio analysis include the absence of an explicit theoretical framework. Nevertheless, ratio analysis remains a simple and quick method that enables financial performance to be compared between firms and over time.

METHODOLOGY

The approach adopted for this empirical research into the profitability of commercial construction companies is to use annual financial statements. The source data was obtained from the Company 360 database, a business tool provided by Dun & Bradstreet. This service collates the financial statements companies submit to the Australian Securities and Investments Commission (ASIC). Only large proprietary companies, defined as one that satisfies at least two of the following criteria: revenues exceeding $25 million, gross assets exceeding $12.5 million, or employs 50 or more people; need to prepare and lodge financial reports. Smaller proprietary companies do not usually lodge financial statements unless directed to do so by the AISC, limiting the amount of financial data available for this analysis.

This data source provides access to a large number profit & loss accounts and balance sheets for companies with their corresponding standard industrial classification (SIC) code. Commercial construction companies are registered under an SIC of 1542 – General Contractors – Non-residential Buildings, Other Than Industrial Buildings and Warehouses. The SIC code is a four-digit numerical code assigned by the US government to business establishments to identify the primary business of the establishment, and is adopted by Dun & Bradstreet, a US company. Some companies report both a primary and several subsidiary SIC codes, and a search for SIC=1542 revealed that a total of 1,155 companies in Australia. Twenty four percent of these companies or 278 are registered in the state of Victoria, our primary location for this study. Only 166 companies reported 1542 as a primary SIC and 27 of these presented sufficient financial data for this analysis. These 27 companies are listed in Table 1.

RESULTS

The revenues of the sample companies range from $14 million to $2.5 billion per year while the total assets range from $6.5 million to $1.1 billion. The profitability of these companies is assessed by examining 5 profitability ratios from 2006 to 2015. These ratios are (i) net profit margin, (ii) EBITDA margin, (iii) Return on Equity (ROE), (iv) Return on Total Assets (ROA) and (v) Return on Capital Employed (ROCE). These profitability ratios are presented in Table 2 as statistical means (μ) of

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these ratios, standard deviations (σ), and finally as an aggregate mean (μ_2) (calculated as a ratio of the sum of profits of the sample companies divided by the sum of revenues).

Table 1 - List of construction companies investigated, along with their corresponding DUNS number and number of employees

	DUNS	Company Name	Employees
1	743145369	ACCIONA INFRASTRUCTURE AUSTRALIA PTY LTD	237
2	740825070	ADCO CONSTRUCTIONS (VIC) PTY LIMITED	125
3	741085880	APM GROUP (AUST) PTY LTD	53
4	750256760	BAY BUILDING SERVICES PTY. LTD.	140
5	753284660	BECON CONSTRUCTIONS PTY. LTD.	153
6	741234116	BUILT VIC PTY LTD	43
7	744119350	CAELLI CONSTRUCTIONS (VIC) PTY LTD	637
8	756701546	CAMILLO CONCRETE STRUCTURES PTY LTD	66
9	751826801	CMW DESIGN & CONSTRUCT (VIC) PTY. LTD.	25
10	741329119	CONTRACT CONTROL SERVICES PTY LTD	42
11	741696306	CREMA CONSTRUCTIONS PTY LTD	200
12	753452770	E.J. LYONS & SONS PROPRIETARY LIMITED	38
13	757403204	FDC CONSTRUCTION & FITOUT (VIC) PTY LIMITED	53
14	750745200	FORM 700 HOLDINGS PTY LTD	892
15	754199677	GEORGE RYDELL CONSTRUCTIONS PTY. LTD.	25
16	745047485	GROCON CONSTRUCTORS (VICTORIA) PTY LTD	50
17	753043637	GROCON PTY. LIMITED	290
18	753662618	KANE CONSTRUCTIONS PTY LTD	270
19	754508836	LLOYD GROUP PTY LTD	15
20	752223581	MABEN GROUP PTY. LTD.	40
21	890711153	MELBOURNE INDUSTRIES PTY. LTD.	20
22	753349588	MERKON CONSTRUCTIONS PTY. LTD.	59
23	744175142	MONACO HICKEY PTY. LTD.	16
24	752067871	MULTIPLEX CONSTRUCTIONS PTY LTD	400
25	752865857	PELLICANO BUILDERS PTY. LTD.	110
26	740985106	PROBUILD CONSTRUCTIONS (AUST) PTY LTD	748
27	746938810	SJ HIGGINS CONSTRUCTIONS PTY LTD	12

(Source: Dun & Bradstreet, 2017)

The mean net profit margin fell from a high of 4.0% in 2006 to 1.4% in 2015. The fall in profit margin in 2010 was indicative of the slowdown in the construction industry despite additional fiscal spending on infrastructure and the construction of schools in response to the global financial crisis. Profit margins have remained at this low level from 2010 until 2015. If all 27 companies are to be considered in aggregate, the highest profit margin was reported in 2008 at 3.6% but declined to a low of 1.2% in 2011, recovered the following year to 2.8%. It was a low 1.6% for 2014 and 2015 indicating that profitability in the commercial

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construction sector remained poor. Very similar trends were observed for EBITDA – an indication of operating performance without taking into account financing, accounting or tax issues. A scatter plot of net profit margins against revenue, shown in Figure 1, indicates that companies with larger revenues exhibit net profit margins within a narrow 2% to 4% band, whereas companies reporting revenues less than $500 million exhibited profit margins from -6% to 10%. When the same data is plotted over time as in Figure 2, all the companies were reporting net profit margins of up to 10% before 2010. From 2011 onwards, a number of companies started to report losses while the aggregate mean profit margins declined. By 2015, 90% of the companies reported net profit margins of less than 2.3%.

Table 2 - Company financial ratios, for years 2006 to 2015

Financial Ratios	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
NPM (μ)	4.0	2.9	3.9	3.1	1.5	2.2	1.4	1.3	1.2	1.4
NPM (σ)	2.3	2.6	2.8	2.6	3.1	3.7	3.2	2.0	2.1	2.0
NPM (μ_2)	3.2	2.8	3.6	3.3	2.5	1.2	2.8	2.1	1.6	1.6
EBITDA (μ)	5.4	4.1	5.4	4.3	1.9	2.6	1.7	1.3	1.8	2.1
EBITDA (σ)	3.8	3.5	3.7	3.7	4.5	5.2	5.0	3.0	3.1	2.8
EBITDA (μ_2)	3.0	4.7	5.5	5.2	4.0	1.7	4.4	3.9	2.6	2.9
ROE (μ)	56.5	1.9	90.8	77.7	21.0	37.2	28.6	30.9	23.2	24.5
ROE (σ)	45.8	128.5	76.6	140.8	45.4	51.9	24.5	34.9	53.1	39.5
ROE (μ_2)	46.4	35.6	43.7	27.8	19.0	9.0	26.1	27.4	19.4	21.0
ROA (μ)	12.0	9.0	17.3	9.3	5.4	7.6	5.4	4.3	4.1	3.9
ROA (σ)	8.5	12.0	11.8	10.4	9.6	6.5	5.1	6.2	6.2	5.7
ROA (μ_2)	7.1	4.9	7.4	6.3	5.0	3.1	7.4	6.4	4.8	5.0
ROCE (μ)	55.8	34.3	93.3	68.5	7.8	30.3	48.5	38.6	29.4	22.7
ROCE (σ)	54.7	86.7	61.4	77.2	74.6	56.4	61.7	41.1	42.3	27.6
ROCE (μ_2)	36.6	52.6	58.6	37.9	25.8	10.3	31.9	31.6	23.7	25.8
TP/TA (μ)	37.8	45.0	43.5	40.1	41.1	38.2	41.3	42.6	41.7	34.8
TP/TA (σ)	18.8	23.7	18.4	19.1	19.3	17.3	16.6	16.0	16.1	17.0
TP/TA (μ_2)	26.1	15.8	21.4	27.2	2.4	24.3	32.4	33.9	31.7	29.0

A similar analysis on the return on average equity (ROE) indicated that these returns were at 40% in 2008 and earlier, but fell to around 20% in 2014 and 2015. This was clearly a consequence of the lower profits during those two years. The return on capital employed (ROCE), which measures the return over the sum of both equity and long-term borrowings, indicated a slightly higher value compared to ROE but the general trends were similar. Pre-2008 ROCE was between 40% and 60% whereas 2014-2015 aggregate was between 24% and 26%.

Return on total assets (ROA), which measures how effectively the construction company is utilising its assets to generate earnings, declined from a high of 7.4% in 2008 to about 5% in 2015. One major characteristic of the commercial construction sector is the existence of

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large trade payables as part of total assets which, on the surface, serves to inflate total assets to such an extent that it dilutes ROA. But on closer examination and analysis, this trade payable may be utilised to finance construction work, allowing under-capitalised companies to take on large projects, where working capital is generated from increasingly larger operations. Other than a year of low trade payable/total asset ratio in 2007, trade credit has remained at between 21% and 27% before 2012 but increased to more than 30% in 2012 and beyond.

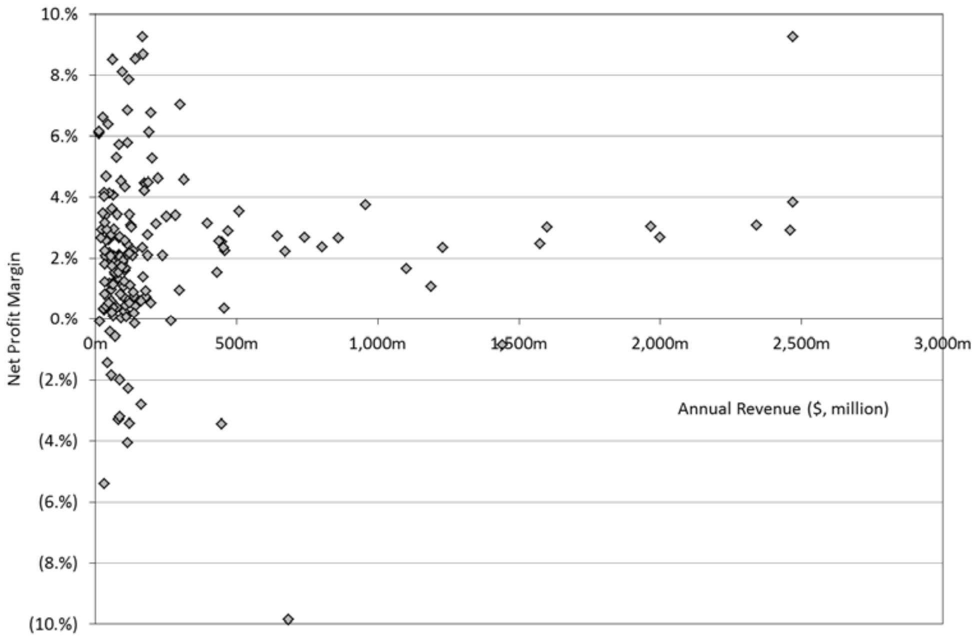

Figure 1 - Net profit margins for sample of commercial construction firms

DISCUSSION

Reported total revenues for the Australian commercial and industrial building construction sector for 2015-16 are $33.5 billion, with a total profit of $1.7 billion (Kelly, 2016). This gives a profit to revenue ratio of 5.0%. Victoria represents 27% of the total Australian construction market. For the large, Victorian construction firms surveyed in this study, the profit to revenue ratio for 2015 stood at a mere 1.6%. Given the industry revenue volatility of 10%, this is a poor and, more notably, unsustainable performance outcome.

The findings confirm that large commercial construction companies in the state of Victoria currently earn a small net profit margin and this margin has declined considerably in recent years. The drastic fall of the aggregated NPM from 3.6% in 2008 to 1.6% in 2015 is particularly disconcerting. Using a different data set and a smaller sample of Victorian companies, Deloitte (2016) also reported declining profit margins that averaged 1.7% in 2010-11 to only 0.4% in 2014-15. From an operational perspective, these construction companies are facing a period of

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increased competitive forces leading to erosion of profits either to maintain or increase revenues. The convergence to a lower profit margin for larger construction firms (represented by revenues exceeding $1 billion) further reinforces the view that average profit margins for the entire sector is declining and that large companies are adopting a strategy of chasing revenues as opposed to chasing profits. Davidsson et al. (2009) have shown, from empirical tests on large longitudinal data sets, that highly profitable companies have decreased risk of poor performance compared to companies adopting a high growth strategy.

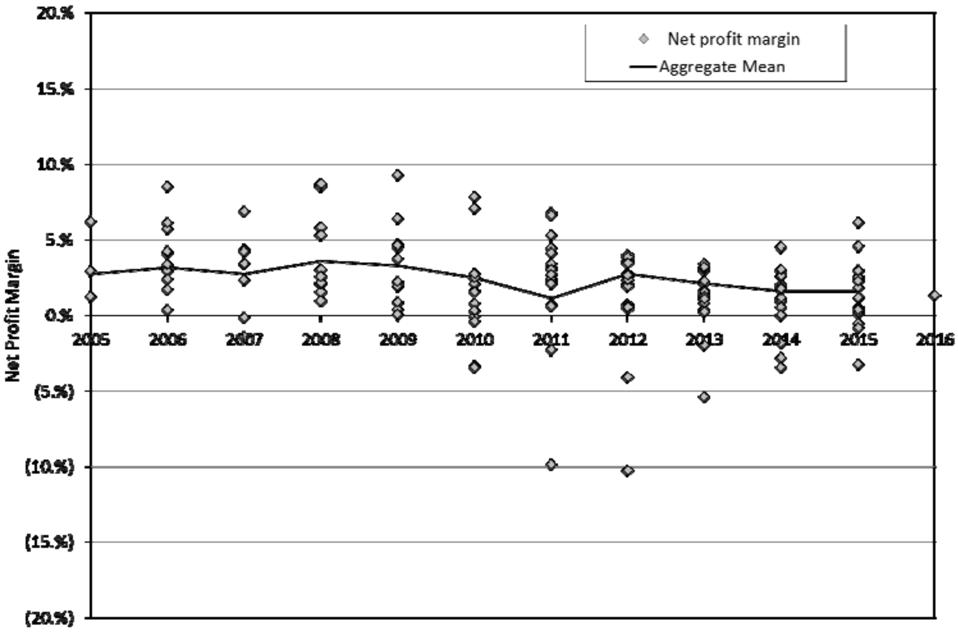

Figure 2 - Net profit margin for years 2006 to 2015

The finding that companies with larger revenues reported lower profit margin contradicts the observations from Fadel (1977) and Akintoye and Skitmore (1991). The circumstances where construction companies can no longer achieve economies of scale or achieve a better profit from greater turnover is clearly disconcerting and needs further investigation. Perhaps the inference to be drawn here is that the industry is entering a phase of intense competition or increasing commoditisation, where no single company within the sector is able to sustain an enduring competitive advantage.

An exacerbating factor in loss of profit is likely the rising costs of wages. While wages for the construction sector stands at 12.2%, compared with 19.5% for all sectors combined, this conceals the fact that some 46% of revenue payments are made out to subcontractors. The average entry-level salary for a construction labourer, at $144,506 (equivalent to $54/hour), is higher than for any other profession, except for medical practitioners. The growth in wages under EBA agreements is stronger in

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building construction than in any other industry. Moreover, wages growth in Victorian construction, at 13.4%, continues to outpace growth in other states.

While the price of construction across Australia has risen at 1.0% per annum, the price rise in Victoria is 1.5%. At the same time the rise in wage costs has risen by 5.0%. Meanwhile, the productivity of labour in the sector has been falling, year on year, since 2004-5. Again, construction labour productivity in Victoria is lower than in other states.

From an investment perspective, the fall of the ROE from 44% in 2008 to 21% in 2015 is similarly disconcerting, but not altogether unexpected given that fall in ROE is proportional to the decline in profits.

The loss of profitability has led to an increase in the use of trade credit in these companies. Ive and Murray (2013) have examined the role of trade credit, defined as the ratio of trade payables to total assets, in order to finance increasing levels of output and turnover in the UK. The trade credit levels from 16% to 27% before 2010 is synonymous to the weighted mean of 19.7% reported for the construction sector in the UK. However, the increase of the trade credit in Victoria in excess of 30% is significantly higher and indicates that these companies are increasingly transferring project and business risks to their suppliers and sub-contractors.

Although there is no evidence in this study to suggest that the poor profitability and returns on capital employed, concurrently with the higher leverage for these construction companies are directly linked to the higher incidence of insolvencies in the sector, the data from 2010 onward suggest that a number of these companies are taking on losses. The construction industry has consistently been over-represented in insolvency statistics between 17% and 20% during this period (ASIC, 2017). The longer these conditions persist, the likelihood that these construction companies will find themselves in financial distress will certainly increase.

CONCLUSIONS

This study has found evidence of a steady decline in profitability for Victorian commercial construction companies for the period 2006 to 2015. The low profitability may be attributed to increased competitiveness in the market, reducing efficiencies, and higher labour costs in the sector. A corresponding decline in returns on equity and on capital employed over the same period is also confirmed. There is also some evidence of a "grow revenue" business model that has previously been suggested to lead to poorer company performance in the longer term.

The implications are significant, and indicate a shake-up in the industry is inevitable. Reducing profits foretell a reduction in industry players. In 2015, the construction sector experienced the highest number of firms

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going into liquidation, with 18% of the country's total. Nevertheless, sector rationalization is also occurring in the form of mergers and acquisitions, where assets are hopefully transferred to those better able to extract efficiencies. A number of Victorian companies have attracted the attention of foreign investors, such as the reported acquisition of 40% Probuild by Wilson Bayly Holmes Ovcon (WBHO) in 2001 followed by a further 49.9% in 2012. More recent foreign investment include the acquisition of Icon Co. in 2015 and Cockram Construction in 2017 by Kajima Corporation, and of John Holland by the China Communications Construction Company (CCCC) in 2014 (Chandler, 2016).

The warning to firms unprepared or unable to adapt, is that a "grow revenue" business model over a "grow profits" approach may sustain cash-flow in the shorter-term but not a viable longer term strategy. Politicians and the wider community should also take note. Failure to address rising costs in the construction industry will not just see project costs go up, but may see needed investment cancelled or taxes increased. A projected 13% increase in labour costs, without accompanying productivity gains, will add $148 million to the current Victorian government's infrastructure shopping list (Deloitte, 2016).

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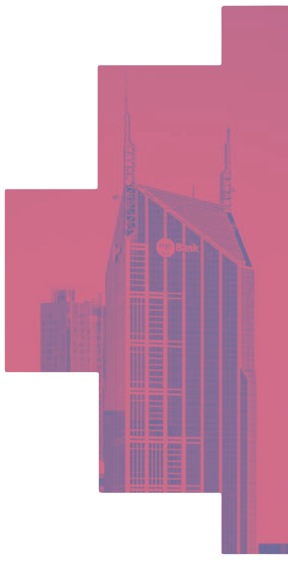

USE OF TIMBER PREFAB SYSTEM FOR ENSURING SUSTAINABLE RESIDENTIAL HOUSING SUPPLY IN NEW ZEALAND

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ABSTRACT

New Zealand housing shortage requires effective approaches to address the increasing demand over the next twenty years. Given the current situation of the New Zealand's housing crisis, it is almost impossible to meet that demand by using the traditional methods of construction. Offsite manufacturing system can help improve housing supply capability in New Zealand. With timber being a very sustainable resource and abundant in New Zealand, timber prefab system offers the most economically and environmentally feasible solution to the housing supply challenges in New Zealand. This research aims to investigate a method that New Zealand construction industry can adopt in the offsite manufacturing system at a national scale to improve the residential housing crisis. Ten interviews and ten questionnaires were conducted with clients, designers, prefabricators, and suppliers to identify the risks and required actions in order to achieve successful application of the system. The impacts of several factors on the system such as barriers, enablers and sustainability aspects of using the timber prefab system were studied as part the research objectives. The results reveal the most sustainable method of residential housing supply in the New Zealand within the acceptable risks, productivity and having a secure government investment support.

Keywords: Housing Crisis, Prefab, Residential, Sustainability, Timber

1. INTRODUCTION

The poor standard of current housing and the inability of too many people on low incomes to access decent housing is causing a group of problems that are avoidable (Howden-Chapman, 2015). Today there is a crisis, not only in access to and affordability of housing in New Zealand, but in the quality of the housing (Howden-Chapman, 2015). An estimated 91% of Greater Christchurch dwellings suffered some type of damage, in which approximately 7.5% of buildings collapsed or required demolition (Dionisio et al., 2016). The New Zealand construction industry council mission is to

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work effectively within the design and construction industry, specifically between regulators and industry stakeholders, to continuously improve efficiency, resilience, quality and professionalism. The New Zealand government started a BIM acceleration committee, as part of a productivity partnership with the goal of 20 per cent more efficiency in the construction industry by 2020. Adding the prefabrication industry to the BIM may cause the significance and positive result in the New Zealand's residential housing industry. Also, modular construction as one of the offsite manufacturing methods can save around half of construction time compared with traditional construction (Mah, 2011, Lawson and Ogden, 2010, Smith, 2011).

Numerous benefits that prefab can offer have been researched in several studies (Te Roopu Taurima, 2016). For example, workers in the factory use lasers to cut the wood and jigs to place the pieces together, the quality is very consistent. The workers are also very efficient because they do the same job repeatedly, which increases their skills and reduces errors. Very little waste is created and no materials are damaged by moisture, which creates a home with very good indoor air quality that is far superior to the average stick-built home knowing the price of a project upfront is important, modular construction can offer far more precision. Therefore, this is especially helpful when building rental properties because an accurate estimate for return on investment can be easily calculated. Knowing the price upfront also benefits investors in that they can know exactly how long it will take to get a return (Te Roopu Taurima, 2016). There are some challenges in the New Zealand prefabricated systems such as project planning, transportation restriction, negative perceptions, high initial cost, coordinate and communication in the modular housing systems (Conducted interviews).

Few studies have looked at the sustainable timber prefab system to improve the housing crisis in NZ. This research contributes to filling this knowledge gap by seeking and analyzing the appropriate benefits and challenges of the prefab system. That may support processes of community and stakeholder engagement and decision-making, to achieve better residential redevelopment outcomes at the wide scale.

2. LITERATURE REVIEW

2.1. Residential housing

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The New Zealand residential industry is in an ideal position to benefit from decades of overseas experience and adopt the knowledge and technique to suit the local context. There is significant scope for New Zealand's residential construction industry to create aspirational industry quality standards or label to enable the customer to better understand the quality of what they are buying (Buckett et al., 2007). The majority of the new housing in New Zealand is detached housing (Page, 2013).

There is a significant concern over the shortfall between increasing population in many of the main urban centers in New Zealand and the rate of construction of the new dwellings. Auckland is particularly hard hit, with around a third of New Zealand's population (QuickStats, 2013). Christchurch has housing pressures relating to a decrease in housing stock and a sudden increase in population (Business, 2013). In Auckland in particular the inflation of house prices and rent has become a major concern (Buckett et al., 2007). The average firm size is likely to increase, which will lead to a significant change in the characteristics of new housing, possibly leading to better quality, enhanced affordability and improved sustainability (Page, 2013).

2.2. Why timber in the residential housing?

As a results of (Ede et al., 2015) concrete is stronger and heavier than timber. The lighter weight of timber structure entails a smaller foundation and therefore economic advantage. The lighter weight of timber is of a particular advantage where sub-soil conditions are poor and prone to differential movements. From the cost point of view, the timber model has a better advantage to the concrete as it appears more economical (Ede et al., 2015). On environmental impact and energy efficiency analysis, timber made buildings are more environmentally friendly compared to concrete structures. Therefore, (Ede et al., 2015) proved beyond reasonable doubt that timber is an excellent material for residential buildings and moderate size buildings in comparison to concrete.

Maximizing the use of timber in future urban developments demonstrated that Auckland's target of a 40% carbon emissions reduction by 2040 could be achieved 20% faster than planned while still meeting the city's future growth needs. This strategy is complementary to, and easy to integrate with, other strategies and policies for greenhouse gas mitigation (Stocchero et al., 2017). In addition, new forms of pre-stressed timber construction being developed at the University of Canterbury have the potential to revolutionize large scale timber buildings. The new technology can be used for multi-story timber buildings up to 10 stories (Buchanan et al., 2008).

In summary, taking the viewpoint of a consumer, three typical houses compared in which steel, concrete or wood is the dominant component. It appears that wood, wood components, and houses built primarily of wood require lesser amounts of energy in their manufacture, assembly, and operation.

2.3. Type of prefabrications

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(1) Component-based prefabrication includes stick and sub-assembly prefabrication. Stick refers to lengths of timber or steel that are pre-cut, pre-sized or pre-shaped puzzle-type pieces brought to site where they are assembled by a builder, as opposed to the traditional construction process which cuts timber to size at site (Bell, 2009). (2) Panelized or non-volumetric prefabrication comprises manufactured panels that may include integrated building services. While panelized elements can be stacked flat for efficient transportation to site, they require more work for assembly at site than modular units. (3) Modular offers designers and architects flexibility which is cost-effective (CIMC, 2017). Interviewee 5: *Modular technology considerably reduces construction time. It is safer, quieter and cleaner than traditional.* Modules are fully fitted out inside, in a controlled factory environment, which results in a high level of quality and repeatability, and leads to significant construction program benefits. In addition, compared to traditional construction, modular construction time can be reduced by 30%-60%. On-site labor is typically reduced by 70% which leads to considerable benefits on site for access, storage of materials and Health & Safety issues in general (CIMC, 2017). Therefore, modular building allows reductions in the overall capital costs by 10%-30%, through greater efficiencies of design, delivery and onsite management. (4) Hybrid systems use "volumetric units for the highly serviced areas such as kitchens and bathrooms and construct the remainder of the building using panels or by another means". (5) Complete buildings are commonly known as portable, relocatable or transportable dwellings in New Zealand and they are a type of volumetric prefabrication where entire buildings are constructed in a factory or yard and then moved to site where they are attached to permanent foundations.

2.4. Benefits of the prefabrication compared to conventional housing system

The merits of prefabrication are potentials, rather than givens, as each individual example of prefabricated housing possesses its own particular systems and processes (Interviewee 4). Prefabrication can potentially offer 'more for less': more quality for less time at site, more known outcomes and less unknowns, and potentially more energy efficiency for less resource use (Interviewee 2). Prefab system is a construction technique in which a building's components are manufactured in a controlled environment (on- or off-site), transported, positioned, and assembled into a structure; only minimal additional work is done on-site (Interviewee 1). Prefabrication is a process of social and economic change whereby a human society is transformed from a preindustrial to an industrial state (Mohd Nawi et al., 2011). It is a part of wider modernization process through the technology system and one of the solutions for this increasing housing demand. Prefab system improves the quality of projects, easier to control, reducing rectification work and lowering the total cost of construction (interviewee 6). Building production in a controlled environment offers many advantages such as minimizing construction time, increasing the quality of buildings, reducing construction cost, enhancing occupational health and safety, and reducing construction waste (Interviewee 7).

A strong emphasis of sustainability needs to be demonstrated through built environment planning, design and construction economics (Mohammad, 2013). The choice of using the prefabricated system in a sustainable commercial development is expected to enhance the quality of life and work for today and future generation. Quality, speed of construction, and cost savings are the main advantages of these systems (Interviewee 3). The expansion of industrialized construction and prefabrication in a controlled environment has allowed issues of sustainability to be addressed more quickly and efficiently (Umair et al., 2015, Nadim and Goulding, 2010).

In summary, the application of prefabricated systems has been encouraged as a means of providing better quality products in a shorter amount of time and reducing both labor and material costs.

2.5. Merits of the prefabricated systems

The merits of prefabrication are established, yet traditional housing methods dominate the construction industry.

Sustainability merits and challenges, in particular, infrastructures have major influence on the attainment of sustainable development, thus project sustainability needs to be considered (Shen et al., 2010). Material usage is thought to be saved by up to seventy-five percent for modular construction (Bell, 2009). Currently forty percent of our country's waste is created by the New Zealand construction industry so there could be great improvements made in the area of waste minimization (Wood, 2008). Potential site benefits of prefabrication include less disruption, noise, pollution, effluence, ground-works, traffic, and fewer deliveries. Environmentally, for every 1% increase in the proportion of prefabricated components, CO_2 emissions decreased approximately 45,505 (kg-CO_2) (Mao et al., 2013).

Social merits include being able to work under cover during inclement weather, having tools and amenities close at hand, and improvements in health and safety (Interviewee 2). Economic merits include the cost savings to customers and developers from a shorter period of financial borrowing as a result of shorter timeframes, and reduced defect liability periods (Interviewee 10). Timeframes and costs will also be decreased by eliminating dependence on weather for site-based construction, easier coordination of trades in-house, and price advantages from bulk ordering.

In conclusion, to take timber housing from the level of unique experimental projects to competitive industrialized production, manufacturers will have to face the challenge of convincing the market that timber is an equally sufficient material as the more traditional concrete and steel.

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3. SCOPE OF THE STUDY

The research focus is to develop the innovative approaches and strategies that NZ construction industry can adopt a national scale to improve the housing crisis. Therefore, The research would be conducted from mainly of the master builders, PrefabNZ, prefabricated builder, and BRANZ associations. Those are necessary as they are some experts that can influence on the NZ's housing crisis. Therefore, it is appropriate in this research to use these people as the unit of analysis in the study.

During the period of 2006 to 2031, the predicted new demand for housing in Auckland may exceed the predicted delivery of new housing by nearly 120,000 (Burgess et al., 2013). Therefore, Auckland was selected as a geographical coverage area for obtaining research information and based on the current number of the housing shortages.

4. RESEARCH METHOD

The use of multiple sources of data and methods, assist to confirm the emerging findings and ensure that data reliability and internal validity is strengthened (Marriam,1998).

4.1. Data gathering

The qualitative and quantitative data collection methods adopted in this study are face to face interviews and distributing the questionnaire survey among the experts. The plan and structure for data collection methods used in this research was designed to ensure that information could be systematically gathered and synthesized across the Auckland.

A personal face-to-face interview was adopted as the data collection technique for the qualitative research phase because it allows an in-depth understanding of the research topic, its relevance to the experts such as NZBuilders, PrefabNZ, and BRANZ members and the prefabricated construction companies to gain more insights into the research problem. The interviews took place in the interviewee's respective offices within the different locations. Ten out of the fifteen companies accepted the invitations for interview, which provided them 14 open-ended questions, pertaining to the current NZ's construction industry and challenges.

After qualitative date collection and based on the formulation of the AHP method for weight assigning, a questionnaire survey was conducted to collect data from selected experts for analyzing the significance of one factor in comparison to the other ones. For this purpose, 10 professionals from the construction industry sectors were invited to compare and assign relative weights to indicate the significance of pairs of factors by using the pairwise comparison.

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4.2. Data analyzing

Data from the face to face interviews were reviewed to find out the barriers and enablers. Then the AHP method utilized to rate enablers and the sustainability ratio of each prefab methods.

The AHP method was developed by Thomas Saaty (Saaty, 1980), and has been extensively studied and refined since then (Zhang and Zou, 2007).The adoption of the AHP method in this step led to generating the matrixes for comparing different factors. Finally, based on the reliable and valid data, the weights of factors were determined within the rating system. In this study, factors are compared to determine how important they are to the decision makers, with respect to the goal.

By changing the problem into a hierarchy of sub-problems, the AHP helps the decision makers to evaluate the decision elements by comparing them to one another using pairwise comparison. A numerical weight or priority is derived for each element of the hierarchy. The adoption of the AHP method in this study leads to generating the matrixes for assessing factors. Rather than prescribing a "correct" decision, the AHP helps the decision makers find the one that best suits their needs and their understanding of the problem.

5. RESULTS AND DISCUSSION

What the NZ prefabricated housing industry can learn from the other countries is customer focus, marketing investment, show-home and dedicated magazines. Also, architect collaborations with established housing manufacturers, widespread education about prefabrication through design competitions, university-led courses and exhibitions.

The New Zealand prefabricated housing industry can learn from the strategy of using a flexible construction system to provide an infinite range of housing configurations, collaborations with well-known architects, offering a range of styles to broaden their marketing base and forming a marketing relationship with an established magazine brand to develop housing products for identified target consumer places. In addition, specific goals can be measured and tracked over time, and hence, timber prefab system can be managed and improved.

The main contribution of this study is to apply the AHP method to rate enablers and the prefab systems sustainability. The primary data was gained from semi-structured interviews with 10 construction practitioners who have had key involvement in the development of prefabricated building system in New Zealand. The outcomes are presented in Table 1.

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Table 1 The result of data analysis from 10 semi-structured interviews

New Zealand's barriers in timber prefab system	New Zealand's enablers in timber prefab system
• Susceptibility of timber to moisture, even in treated conditions • Susceptibility of timber to fire, even in treated conditions • Perceptions around the legacy of leaky building issues in the industry • Durability issues compared to other materials • Structural integrity issues when exposed to adverse weather conditions (e.g. warping, twisting, shrinking, deflections	• Abundance of timber resource in New Zealand • Environmental sustainability properties of timber use • Resistance to earthquake due to its lightness • NZ's familiarity with timber technology • Economy in the short term (long term economy in question) • Advances in structural/engineered timber technology (LVL, Glulam, SG) • Advances in more environmentally friendly treatments to timber

The AHP method was then applied twice to rank and analyze the complex questionnaire data and the rating systems of the barriers and the sustainability of the prefab methods. Therefore, two questionnaires have been developed and distributed among the experts, including the engineers, contractors, consultants and employer parties.

Figure 1 reveals that the *Advances in structural timber technology* is the most important factor in enablers with 22.5%. In addition, *Resistance to earthquake* and *Economy in short term* are the second important factor with 16.2% and 16.0%, respectively. Moreover, *Environmental Sustainability* and *Advance in more environmentally friendly* with 12% have the same weights in the enablers of the timber prefab system in New Zealand.

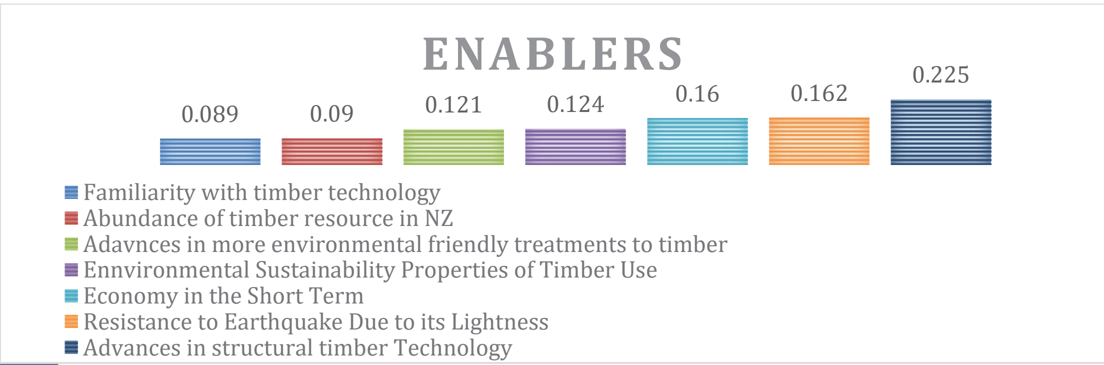

Figure 1 Influencing the enablers in improving wider uptake of the system as preferred choice in the NZ housing construction

Figure 2 illustrates the weight of sustainability in five different prefab systems. Therefore, *Modular* and *Whole house* system have the most influences on NZ's sustainability with 35% and 30.2%, respectively.

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Although, *Hybrid* system has 20.6% influence, *Panelized* and *Stick and Framing* have the least important factors with 9.5% and 4.7%.

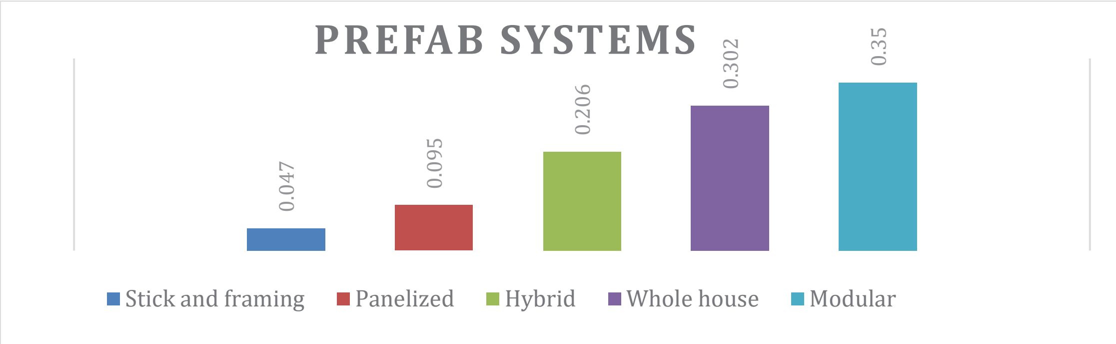

Figure 2 Prefab systems and their influence on NZ's sustainability

6. CONCLUSIONS

The study included both qualitative and quantitative aspects to contribute to the research with in-depth literature, interviews and surveys to determine and assessment of enablers and barriers faced by New Zealand's prefabricated housing system with respect to their sustainability. As prefabrication is an important method to address issues of housing affordability, this study reveals that the timber modular housing system with respect to advances in their structural technology is the most sustainable timber method in the New Zealand within the acceptable risks and productivity. Although, Stick and Framing systems are the least sustainable prefab system. The research method can be generalized for other countries, enablers and types of prefab systems.

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DEVELOPMENT OF A COLLABORATIVE TRAINING PARTNERSHIP IN THE NEW ZEALAND CONSTRUCTION INDUSTRY

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ABSTRACT

In 2015 a first tier New Zealand commercial construction company approached the Department of Construction at Unitec regarding the company's professional development training. The primary aim was to focus on introducing a more collaborative best practice approach in a competitive construction environment to some 300 middle management onsite construction staff over a 4-5 year period. The company was seeking a partnership with an innovative tertiary provider to offer specific professional development expertise, and give effect to the company's strategy for ongoing and accelerated growth. The delivery approach needed to have the greatest possible impact on staff in terms of engagement and knowledge transfer. How was this academic-industry partnership built? In this first part of the research, the philosophical and practical approaches, timelines applied by both parties, the steps of how the partnership was developed from the initial interviews through to the developed successful partnership are described. The preparation and delivery of this practically based, real-time bespoke programme alongside the learnings will be described in later stages of the research in a series of publications.

Keywords: Collaboration, Building Relationships, Trust, Partnering, Organisational Learning.

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INTRODUCTION

The construction industry is known as a complex, competitive and often an adversarial environment to work in (Egan, 1988; Egbu, 2004; Latham, 1994). Construction has struggled to maintain productivity and profitability and is accused of low levels of innovation and collaboration, and being poor in knowledge management, not to mention organisational learning (Barlow, 2012; Winch, 2003; Xue et al., 2014). It is difficult to say which one is the cause and which one the effect, but what is certain is that surviving and succeeding in such an environment requires complex responses. Research into the application of innovation, collaboration and organisational learning demonstrates how leveraging these concepts can address productivity and profitability issues in the industry. Skill development and knowledge sharing are seen as the key factors in enabling organisational learning and innovation and through that, an increase in productivity (Esmi and Ennals, 2009).

In late 2015, Hawkins Construction, a tier one New Zealand construction company, approached the Department of Construction at Unitec (Institute of Technology in Auckland, New Zealand) with an opportunity to deliver professional development training to their middle management. At the time, the 'Project Excellence' programme was being delivered by a private training establishment. Discussions between Hawkins and the Department of Construction quickly revealed that the Department had the skills, knowledge and capability to add value to the Hawkins' programme. The only limitation facing the Department was available capacity to develop and deliver the programme, as it was bespoke in nature and would sit outside the Department's normal business model. This study describes how the business venture between Hawkins Construction and the Department of Construction was procured, and resulted in a successful industry-academia partnership, in 2016.

BACKGROUND

Hawkins

The Hawkins Group has a long history in the New Zealand Construction Industry and has been steadily growing over the last 70 years. Recently, the company wanted to accelerate growth by lifting revenue. In order to achieve ongoing growth, the professional development of Hawkins staff was seen as an important ongoing strategy. To provide this professional development Hawkins set up a Business School. To guide the School's activities, a framework was established, see Figure 1. A key aim of the School was to provide 'blended learning opportunities' for Hawkins' employees (Wood, 2015).

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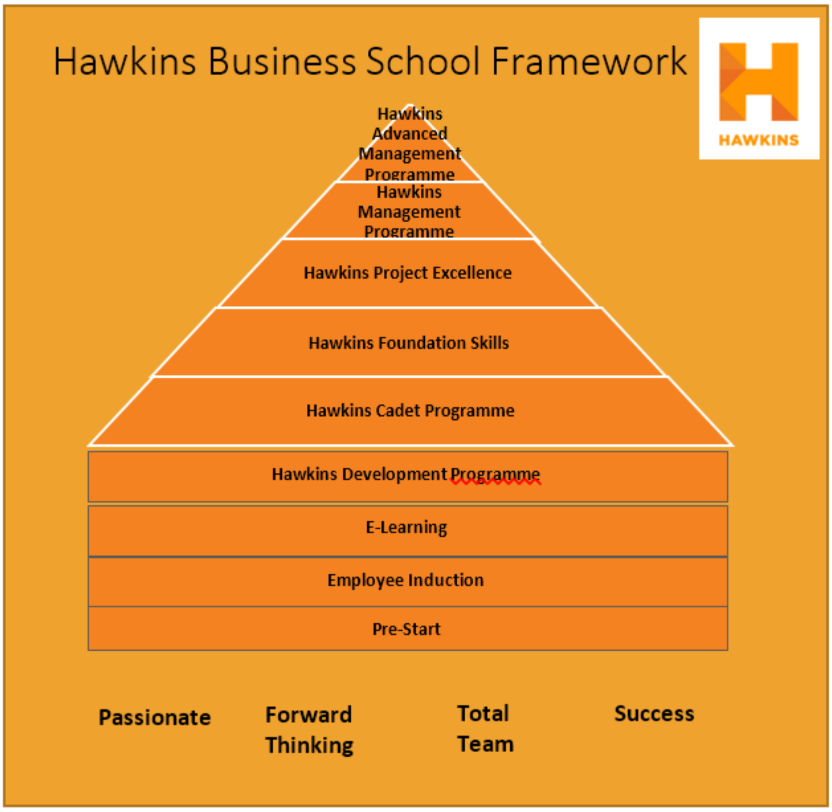

Figure 1 Hawkins Business School Framework
(Source: Brenton-Rule 2016)

The Hawkins' Business School is assisting in the development of the organisation's culture, and in particular, building capacity to innovate and work collaboratively through adopting industry best practice. As a result, the Project Excellence programme for middle tier managers was developed and then delivered for the first time in 2015, in conjunction with a private training establishment over a period of a year, and consisting of the following modules:

- Excellence,
- Supply Chain Management,
- Collaborative Working,
- Lean Construction,
- Construction Management,
- Project Management.

The programme was delivered to 50 middle tier managers who undertook pre-course work activities and post course assessments (Hawkins Project Excellence Prospectus 2015).

Towards the end of 2015 Hawkins undertook a review of the Project Excellence Programme, finding that whilst the programme had been successfully delivered, there were some aspects that the company felt could

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be improved. Hawkins decided to contact a number of other educational providers to identify how extra value could be added to the programme. Unitec was one of those providers that were contacted in the latter part of 2015 to discuss the Project Excellence programme and to investigate whether Unitec was interested in getting involved.

Unitec

Unitec is a government owned Institute of Technology (strictly a Polytechnic under the NZ Education Act 1989), located in Auckland New Zealand and offering tertiary level programmes to domestic and international students. Diminishing government funding for domestic students has meant the Institute has had to operate within tighter budgetary constraints for a number of years. In response to this new environment Unitec reviewed its strategic plan and developed some new key strategic drivers being:

- Meeting the needs of the community
- Enhancing the student experience
- Innovation in teaching and learning
- Being an excellent business (Unitec, 2009).

In line with this strategy, departments within Unitec were encouraged to investigate and expand offerings, including developing short courses and/or professional development programmes. The Department of Construction has been offering undergraduate programmes for over 20 years. The Bachelor of Construction programme is well known by the industry, with the majority of Construction Management and Quantity Survey graduates within the Auckland and international market having studied and graduated from Unitec. The programme has RICS, PACS, NZIQS and NZIOB accreditation. At the time Hawkins approached the Department there was a risk that Unitec may not have been able to provide the support needed in terms of staffing resources to develop and deliver an effective programme for Hawkins. There were a number of significant management changes and institutional changes taking place and these caused a level of disruption in terms of allocating resources and responsibilities.

To mitigate the risk, Unitec's Business Development Unit (BDU) was approached for advice, and it was agreed to work collaboratively together on this opportunity. The first step was to appoint a specialist to the project who had both in-depth construction knowledge and teaching experience. This newly appointed Project Curriculum Advisor (PCA) immediately started working with Hawkins to understand their needs, and this included interviewing attendees of the 2015 course, speaking to Hawkins' Leadership and working with those who had responsibility for the project

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development programme. The BDU also provided direct input financially as well as advice in the preparation and delivery of the partnership proposal.

METHODOLOGY

A descriptive and interpretive case study research approach has been conducted from the perspective of the main contributors to the industry-academia relationship, being Hawkins and Unitec. Denscombe (2007) identifies a case study as a valuable approach for focusing "on just one instant of the thing that is to be investigated" (p35). In understanding the phenomenon, the use of descriptive and interpretive techniques provides a board opportunity to capture the elements involved, (Liu and Fellows, 2015). In order to apply the interpretive research technique, the case is described in terms of the participants' experiences and drivers. Data has been collected from personal reflections, records of meetings, formal agreements and associated documents established to undertake the delivery of the potential training.

DEVELOPMENT PROCESS

The Head of Department Construction briefed the Project Curriculum Advisor on the approach by Hawkins and what stage the programme negotiations had reached, and this included documentation provided by Hawkins. A meeting was arranged in October 2015 between Unitec and Hawkins' General Manager Human Resources, and the Training and Recruitment Advisor, who provided the background on the company's approach to training and the new initiatives that were put in place. This included the following:

- The Advanced Training programme (facilitated by Auckland University - 2015),
- The Project Excellence Programme (facilitated by the Private Training Institution 2015),
- The Cadet Training programme (facilitated by Wintec in 2016).

These were all new initiatives. Hawkins were pleased with the Advanced Training Programme and had committed themselves to Wintec's inaugural delivery for 2016 of the Cadet Programme. The focus for Unitec at this point was to find out what Hawkins were seeking to achieve in the Project Excellence delivery for 2016.

From the discussion, it was clear Hawkins needed Unitec to respond as pro-actively and quickly as possible and this would set a benchmark for the

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relationship with Hawkins. The following approach was agreed by the Unitec Project Team:

- Respond within 24 hours as far as practicable,
- Try to actively identify likely issues and provide possible options for consideration,
- Work in partnership and stay focused on the end goal at all times.

After the meeting, written confirmation of the proposed actions was sent within two days highlighting what had been agreed between the parties at the meeting. This quick response was a first step in building a positive partnership with Hawkins, who confirmed that the key points had been identified and this was followed with a "link" phone call between Unitec and Hawkins. Within one week of the initial meeting it was agreed Unitec would undertake further research, in order to clarify Hawkins' specific needs in terms of the Project Excellence Training Programme.

A meeting was arranged for Unitec to interview four of Hawkins' middle manager participants that had attended the Project Excellence Programme, in 2015, followed by meetings with the General Manager Construction and General Manager Infrastructure.

A meeting was also held with potential Unitec delivery facilitators to discuss the partnership opportunity and possible delivery strategies. The idea was met with a sense of excitement, and the meeting turned into a 'Brain Storming' session. The keypoints of which were added to the partnership proposal. In total it took over two months to complete the negotiation process and secure the contract for Unitec, refer Table 1 below as it provides a summary of the timelines involved in the development of the Project Excellence programme.

TABLE 1 PROGRAMME DEVELOPMENT TIMELINES

Time line -2015	
14/10	– Initial interview between Unitec and Hawkins
16/10	– Respond to meeting with draft of discussions and clarifications (Unitec)
23/10	- Hawkins reply to above discussion and organise meeting with others. (Hawkins)
28/10	– Meet with previous participants, 2 senior managers (Unitec and Hawkins)
5/11	– Meet with the potential Unitec team to formulate a proposal and gain commitment (Unitec)
13/11	– Submit proposal draft to Hawkins (Unitec)
17/11	– Hawkins request cost estimates (Hawkins)
17/11	– Cost estimates submitted (Unitec)
24/11	– Hawkins enquire as to government funding (Hawkins)

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9/12	– Presentations by Unitec including 2 funding options (Unitec)
16/12	– Meet with Hawkins to discuss proposals (Unitec and Hawkins)
17/12	– Confirm that partnership will go ahead (Hawkins)

DISCUSSION

The key drivers that created the successful industry-academia partnership between Hawkins and Unitec resulted from the time spent establishing Hawkins' actual needs and Unitec's willingness and ability to form a meaningful training relationship. Those involved had a mix of construction industry experience, managerial expertise, research and teaching knowledge from diverse construction and management backgrounds and experience. They shared common drivers, being to increase productivity and collaboration in the construction industry. The selected literature used was a selection of relevant published material that underpinned the actions taken by Hawkins' and Unitec when building the collaborative relationship and partnership.

The key success aspect for securing the Project Excellence programme was the importance given by Unitec to developing a strong relationship with Hawkins. The relationship was built on the principles of partnering where trust is developed through open communications. Patterson (2016) identified the importance of effective communications in developing trust and loyalty during the first phase of relationship building. Academic institutions are often cited as being poorly equipped to respond in a flexible way to industry needs (Adler et al., 2011; Schofield, 2013; Tumbas et al., 2016). Therefore, an approach was needed by Unitec to overcome these likely barriers.

Both parties quickly recognised that immediate steps were needed for ensuring that the relationship could be built on trust. However, relationship building for new ventures was not specifically resourced within the Department of Construction. It is not uncommon for businesses to be ill equipped to respond to new ventures (La Rocca et al., 2013). Focusing on relationship building ahead of product needs is considered paramount in new ventures (La Rocca et al., 2013).

A credible point of contact for both organisations proved to be a key success factor and was a key stipulation by Hawkins. This worked well and became a cornerstone of the programme. The PCA appointee was an experienced academic and highly experienced Construction Manager. This offered an opportunity to tailor a bespoke programme that fitted Hawkins commercial needs, and Unitec's academic drivers. Schofield (2013) identified that in order to create successful collaborations where academic and industry

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knowledge transfer opportunities can exist, there needs to be a strong understanding by academia of the industry contextual drivers. The Hawkins contact person was from a Human Resources (HR) background with a clear focus on providing a value driven training programme. Zhai, Liu, and Fellows (2014) have demonstrated that HR practices can improve organizational performance in the construction industry through mechanisms such as working collaboratively with providers on tailored programmes. This approach did pose a significant commitment by both organizations as there was a high level of activity generated throughout the process. It worked because Unitec's PCA had experience in both industries and was able to anticipate a lot of the potential barriers to success. While the Hawkins' person had an excellent understanding of their organisation's personnel and likely constraints. Ankrah (2013) researched into successful instances of University-industry inter-organisational knowledge transfer relationships. The development of a theoretical framework by Ankrah, (2013), demonstrated the approach taken by Unitec and Hawkins aligned well in terms of the Formation Phases that resulted in the final organisational structure.

As the relationship developed, it was clear that the underlying philosophy for developing the programme was one of collaboration between Hawkins and Unitec. "A philosophy based on successes drawn from industry, such as increasing innovation and organizational learning, when engaging in this behaviour", (Adler et al., 2011; Cheung et al., 2015). The shared wish to collaborate provided the context Hawkins and Unitec set for this training programme. Oberg (2016) identified that parties that explicitly share their collaborative identities increase their effectiveness. In order to achieve a collective approach, the key for Hawkins was that Unitec was prepared to listen, adapt and offer suggestions. The key for Unitec was that Hawkins was also prepared to listen, adapt and offer suggestions. As a consequence, the relationship was based on a pro-active problem solving approach by both parties.

CONCLUDING STATEMENTS

Early engagement of the Unitec project team played an important role in this successful collaboration. There are many barriers to academic-industry collaboration, as it requires a higher level of commitment and activity (Tumbas et al., 2016). With an effective project team involved, needs were identified and responded to quickly. This proved to be a key step for creating trust in an industry-academic partnership. The result of industry-academic collaboration is the opportunity for new and improved products (Tumbas et al., 2016). Both Hawkins and Unitec were explicit about their focus on building a relationship that was built on trust and collaboration. This focus was key to both how the programme was later developed, and the associated programme content. Success was realized in securing the Project Excellence programme, by not only building a solid

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collaborative relationship, but also because of the confidence Hawkins had in the Unitec delivery team.

Further Research

As noted, further publications are planned that will focus on the development of the bespoke programmes and their collaborative and innovative delivery.

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The Australian Residential Property Market: A Study on Foreign Real Estate Investment

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ABSTRACT

This research focuses on determining the significance of foreign investment in the Australian residential property market subsequent to the Global Financial Crisis 2008. Quantitative models built on secondary data were tested on two residential property markets comprising Metropolitan Melbourne and a key suburb in the Victoria State, Australia. The relationship between the house price performances and various leading offshore and local Australian economic indicators were assessed. As a result of the increasing relevance of globalisation and Asia Pacific private wealth in the Australia, foreign real estate investment has impacted significantly the Melbourne residential property market performance. The result of this study provides a better understanding on the relationship between the Australian residential property market performance and the emerging significance of the foreign investment drivers. A better understanding of these foreign investment determinants will assist policy makers to effectively manage the Australian residential property market without compromising the steady flow of foreign real estate investment. The result of this study is believed to yield findings that can assist the researcher, property market operators and investors in the evaluation of foreign investments in the Australia residential housing market.

Keywords: *Australia, Residential Property, Housing Markets, Foreign Real Estate Investment (FREI), Asia Pacific Private Wealth.*

1. INTRODUCTION

1.1 The Australian Residential Property Market

Australian capital city house prices grew 1.4 per cent in December from November in 2016 with an annual growth of 10.9 per cent since 2015, representing the fastest pace since Global Financial Crisis (GFC) 2008 (Glynn, 2017). House prices in both Sydney and Melbourne were at record levels and the media alleged that house prices in Australia went beyond the reach of the majority local buyers especially in desirable locations since 2014 (AFP, 2014, Birrell, 2013, Economics, 2014). Subsequent to the GFC 2008 the national dwelling prices rose by 19% whilst the household incomes rose by a mere 9.2% as per estimates from the ANU Centre for Social Research and Methods. In September 2016, the national house price to income ratio was 6.9 times

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(7.2 times for houses and 6.4 times for units) compares to 4.3 times (4.2 times for houses and 4.8 times for units) 15 years ago. 36.8% of a household's income was required to service an 80% Loan Value Ratio (LVR) mortgage in September 2016 compares to 26.8% of household income in September 2001 (CoreLogic, 2016).

The National Australian Bank highlighted that the Foreign Real Estate Investment (FREI) could have been the cause for the Australian capital cities house prices to rise by 6.0% in 2014 and 5.0% in 2015 in the. Approximately 16% of the total sales in Australian new housing markets were transacted into the hands of foreign buyers in 2015, where foreign buyers' involvement reached 21% in NSW and Victoria (NAB, 2015). AFP (2014) estimated that 18% of new dwellings in Sydney and 14% in Melbourne were purchased by foreigners in 2014. Chinese investors and newly arrived migrants were singled out as the major FREI buyers in Australia and they are expected to invest approximately AUD44 billion into Australia residential real estate market by 2021 (Janda, 2014). Figure 1 shows the trend of number of residential real estate approvals for foreign investors in Australia from 2006 to 2012.

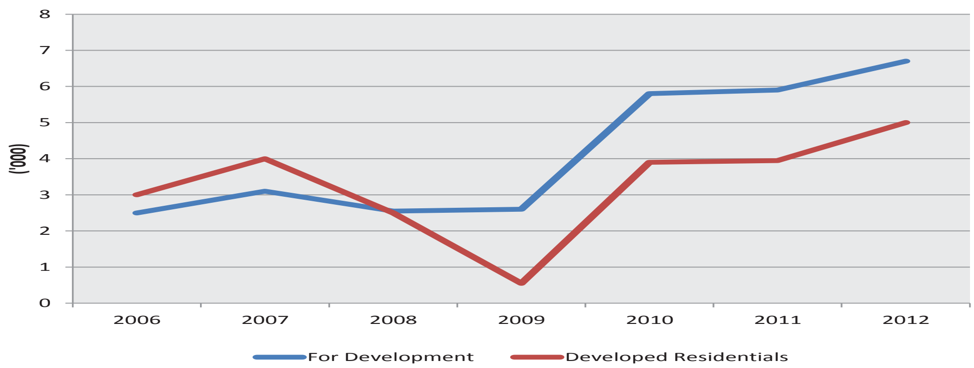

Figure 1 Residential Real Estate Approvals for Foreign Investors (Source: FIRB 2014)

Figure 1 shows the significant lift in both the Australian house prices and the foreign interest in the Australian residential property market. In 2014 the Australian treasurer initiated a formal inquest to the Australian Foreign Investment Review Board (FIRB) to investigate into the Australia's foreign investment policy related to Australian residential real estate. In his reply to the inquest, FIRB chairman Brian Wilson explained that although it was the government's intention to control illegal buying of Australian residential properties, the ability to uncover and prosecute illegal buying by foreigners was limited (Rose, 2015). In the midst of media highlights on the foreign buying being the main reason for the rising house prices, equally noteworthy reports emerged suggesting that FREI may have played relatively minor role in the Australian house price growth (Guest and Rohde, 2015, Soos, 2012). Commonwealth Bank (2014) explained that foreign investors' demand was only a marginal contributing factor to the hike in Sydney and Melbourne house prices.

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There are clear indications for a need to research on the FREI activities in the Australian residential property market. The focus of this study is to determine whether there are historical evidences of a relationship between overseas investments and the residential housing markets performance in Melbourne. This study is expected to yield empirical evidence that will assist the Australian policies makers in harmonising the much needed foreign investments yet maintaining the affordability of housing market in Australia. The findings of this study can assist the researcher, property market operators and investors conducting evaluation on the Australia residential housing market.

2 LITERATURE REVIEW

2.1 FREI and the Traditional Determinants

In this global liberalisation era, the potential benefits derived from the international real estate investment strategies resulted in the inclusion of real estate as a common asset class in any international investment portfolio analysis (Sirmans and Worzala, 2003). The real estate sector had successfully attracted significant interest from international investors, due to its increasing level of liquidity, superior returns and improved opportunities for diversification (D'Arcy, 2009, Topintzi et al., 2008). Other empirical studies seem to suggest that international real estate investment could be regarded as a hedge against excessive risks associated with equity investments (Fereidouni and Tajul Ariffin, 2013, Hoesli, 2004, Moshirian, 1999, Sirmans, 2003, Wilson, 2003). Evidently, cross border foreign real estate investments is on the rise in this global liberalization era (D'Arcy, 2009, Topintzi et al., 2008, UNCTAD, 2009, UNCTAD, 2013).

Foreign Direct Investment (FDI) in real estate markets had experienced significant growth in many countries (UNCTAD, 2011). The increasing cross border activities in real estate market was particularly noticeable in China which observed FDI in real estate market went up to almost 50% of the total China's FDI in 2012. In India, real estate ranked second only to India's computer software industry in 2007 FDI (Economist, 2008). Evidently, cross border foreign real estate investments is on a rise in this global liberalization era (D'Arcy, 2009, Topintzi et al., 2008, UNCTAD, 2009, UNCTAD, 2013).

The main attractions cited for the top foreign investment destinations include stable political and social environments, sound legal and regulatory systems, successful market system, and leading competence in science and technology and education. The drivers cited by Schiesinger (2015) on FREI buying into Australian residential property market were better investment fundamentals, the opportunity to acquire freehold property, higher yields, more stable economic environment and the ability to borrow up to 80 % in Australia. The other two main reasons were availability of education for children to study in Australia and this in turn forms part of a future plan to migrate to Australia due to better living conditions (KPMG, 2014). Other major factors that drove the housing market demand in Australia include:

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i. The population growth attributable by an increased level of skilled migrant intake. The recent migrants were equity strong and they purchased residential properties sooner than many unskilled migrants.
ii. Competition with mining and infrastructure for skilled labour and materials had limited the supply of residential properties.
iii. Higher number of granted education visas.
iv. Real estate has a proven track record for self-managed super funds.

Source: CommonwealthBank 2014

In the midst of FREI activities in the Australian residential property market, Commonwealth Bank (2014) highlighted that the normal investment theory and law of demand and supply was perceived inadequate to explain the reasons of offshore investors' preference in Australia residential properties over other parts of the world. There is an apparent lacking of studies assessing the recent real estate investment decision models from a different perspective based on the emergence of new economic fundamentals subsequent to GFC 2008. A more extensive research into factors causing the surge of housing demand in Australia cities has become desirable.

2.2 FREI subsequent to GFC 2008

Capgemini (2015) and Savills (2014) identified two emerging trends in FREI that will have a significant impact on the world real estate market. The Asia Pacific private wealth and High Net Worth Individuals (HNWIs) are set to overtake western countries' HNWIs as the biggest investor in global property market investments. A new trend has emerged after the GFC 2008 as the sovereign wealth funds, wealth management companies, private bankers and wealthy families have stepped into the property market arena that corporate bankers have deserted and many of them purchased residential properties. Figure 2 demonstrates the trends and compositions of private investment in global real estate for the period of 2007 to 2012.

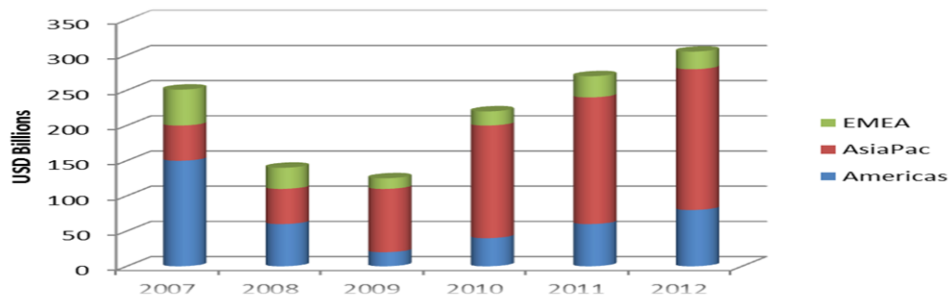

Figure 2 Private Wealth Investment in Global Real Estate (Source: Savills 2014)

Figure 2 reveals that the private wealth investment in global real estate had recovered from the low levels of 2009. Private wealth investment in global real estate had surpassed the highest level in 2007 and attained USD300 billion in 2012. The increasing Asia Pacific private wealth was the key driver that to the cross border investment activities seeking higher return and diversification (KPMG, 2014, Savills, 2014). The growth of High Net Worth Individuals (HNWI)

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in Asia and their investments in cross-border real estate transactions had impacted the world real estate investment landscape (KPMG, 2014). The rising private wealth in Asia Pacific was believed to be the driver that increased the cross border investment activities seeking higher return and diversification and many of them purchases overseas residential properties (KPMG, 2014, Savills, 2014).

3 THE MODEL

This research intends to rely extensively on a research model providing the much needed systematic platform for both local and FREI determinants investigation. Offshore elements and influences will be systematically built into the research modelling to facilitate organised analysis on various capitalist factors. Following the review of various studies conducted specifically on FDI investments abroad, it is conclusive that of equal importance, if not more, should be placed on the investigation on the source of FDI in determining the factors affecting FDI in the host country. Exchange rates, size of the share market, balance of payments, trade flows, cost of capital, economic growth were identified as major "push factors" for investment in real estate abroad (Culem, 1988, Cushman ,1987, Frey et al., 1985, Froot et al., 1991, Goldberg and Johnson, 1990, Moshirian and Pham, 2000, Nigh, 1986). Instead of merely conducing studies relying on local factors, Figure 3 illustrates the proposed "Higgins & Peng" model providng an additional assessment platform accomodating the impactful influnces exerted from the overseas on the local market (Wong, 2017):

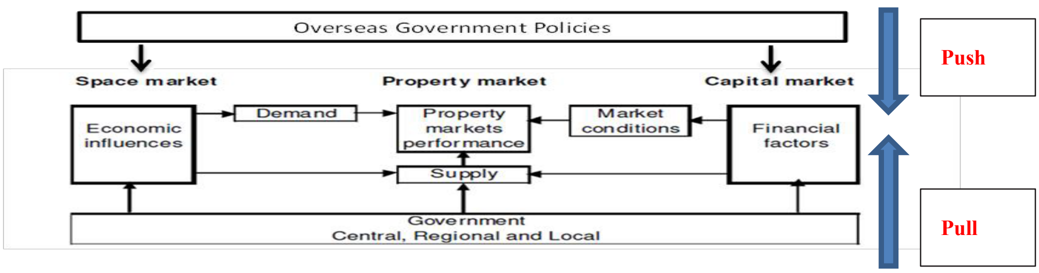

Figure 3 The "Higgins & Peng" Model

Figure 3 illustrates an added component of 'Overseas Government Policies' (from which the offshore investors originated) that impacts and influences the space and capital markets of the host country were duly incorporated in the "Higgins & Peng" model. It is believed that the resultant economy conditions of the offshore government policies have meaningful influences over the foreign investment outflow from the source country and emerges as impactful effects over the Space and Capital market in the host country. Importantly property market supply conditions are very much associated with the policy implementation of local government agencies or in other words, not related to offshore government policies. The "Higgins & Peng" model provides the

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fundamental platform of assessment for various determinants of foreign investments into the Melbourne residential property market for this study.

4 QUANTITATIVE FORECASTING MODEL

A predictive quantitative design involves correlational research and uses statistical analysis on the relationship between two or multiple variables to forecast the future (Tashakkori, 2010). This research falls into this classification of "predictive" design method, whereby house price performance in the selected suburbs will be forecasted to predict the future trend and to validate the model. Quarterly median house prices starting from the year 2003 to 2013 are collected for Australia, Melbourne Metropolitan and the one representative suburbs from the ABS and the Real Estate Institute of Victoria (REIV) database. Factors associated with the foreign investment were analysed alongside with the traditional leading economic indicators in both correlations and regression analysis to explore the inter-relationship of the house prices and the leading economic indicators. Three statistical analysis methods were applied to analyse the strength of the relationships between the Dependant Variables (DV), ie. Quarterly Median House Price Movements and the Quarterly Independent Variable Movements (IV) from 2003 to 2013, ie. the Australian Leading Economic Indicators to confirm the validity of the model, namely:

i. **Lagged Economic Indicators** – the IVs will be lagged for eight quarters or a two-year lag to provide sufficient time for the macroeconomic activities to flow on to the residential property performance.

ii. **Correlation Matrix Pearson Correlation Coefficient (R^2) –** to analyse the nature and relationship between the key economic factors of Australia against the house prices of the selected area of interest. 't' tests at the 95% and 99% confidence levels are applied.

iii. **Multiple Linear Stepwise Regression –** using the ordinary least squares method, forecasting models are built to predict that the relationship between the predictor (IV) and DV. The single regression equation to assess the correlations between the house prices and various independent variables can be expressed as:

Regression Model	Equations
HOUSE PRICE MOVEMENT)$_t$	ƒ (**Space** datasets $_{t \ldots t-2, \ldots}$) + (**Capital** datasets $_{t \ldots\ t-2,}$ …) (**Property** datasets $_{t \ldots\ t-2, \ldots}$)

Three key statistical tests are used to confirm the validity of the residential property forecast model:

i. **Coefficient of determinant** (**R^2**) - R^2 reflects the proportion of variability in the DV that can be explained by a linear relationship with the predictor variables.

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ii. **Sig-value or p-value -** If the Sig-value or p-value is less than 0.05 significant levels, we reject H_0. There is statistically significant evidence that the data fits a linear regression model

iii. **Statistical test for bias (t-test) -** to determine if there is bias and the errors are normally, or nearly normally, distributed.

iv. **Durbin Watson Statistics (DW)** - this is a test to detect patterns in a series of errors.

The main statistical software for this analysis was SPSS. The subprogram 'Multiple regressions: enter, stepwise and forward models were used to provide an acceptable regression equation to assess the correlations and predict future residential property performance. A significance level of 0.05 with a non-zero intercept was chosen as the model parameter.

5 OUTCOME

Part one of the quantitative research involves descriptive analysis on a decade of ABS census data and the market updates in search of a suburb in the Australian State of Victoria that attracted the most overseas settlers between 2003 and 2013. Clayton's house prices increased the most during the assessment period. House prices in Clayton increased by 120% comparing 2002 and 2013. Melbourne Metropolitan and Australian house prices had increased 60% and 40% respectively.

In part two of this research, statistical testing techniques including Pearson Correlation Coefficient and Stepwise Time Series Regression were employed to provide two forecasting models to confirm the validity of determinants. The market capitalist factors were evaluated both in terms of correlation and significance in relation to the individual market residential property market performance. The result of the stepwise multiple regression analysis is presented in Table 1:

Table 1 Single Equation Regression Model for Melbourne Metropolitan and Clayton Residential Property Market

Melbourne Metropolitan $R^2 = 97.2\%$

Variables in Model

	Variables	Description	Lagged	B-value	Coefficient	T-test	Sig.	DW test
1	10BondCurr	10-year Government Bond Yield	Current	0.311	0.614	13.566	0	
2	BuiltCurr	Building Plannings Approval	Current	0.203	0.391	8.279	0	
3	Forex5	Foreign Currency Exchange	15 months	-0.18	-0.249	-5.23	0	
4	GDP6	GDP Growth	18 months	-1.404	-0.167	-3.552	0.002	
5	ASXCurr	ASX 200 Index	Current	-0.05	-0.171	-4.446	0	
6	NewHse5	New Housing Supply	15 months	-0.085	-0.141	-3.486	0.002	
7	NOM5	Net Overseas Migration	15 months	0.074	0.231	3.376	0.002	2.595

Multiple Linear Regression Equation =

2.38+0.311(10BondCurrent)+0.203(BuiltCurr)-0.18(Forex5)-1.404(GDP6)-0.05(ASXCurr)-0.085(NewHse5)+0.074(NOM5)

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Clayton $R^2 = 93.8\%$

	Variables	Description	Lagged	B-value	Coefficient	T-test	Sig.	DW test
1	10BondCurr	10-year Government Bond Yield	Current	0.552	0.579	8.699	0	
2	NOM3	Net Overseas Migration	9 months	0.352	0.572	6.005	0	
3	Built$1	Building Activity-Residential Built($)	3 months	1.177	0.551	7.719	0	
4	GDPCurrent	GDP pe Capita	Current	6.585	0.35	5.918	0	
5	Save1	Net Saving - Current Price	3 months	-0.038	-0.206	-3.601	0.001	
6	MRate3	Mortgage Rate	3 months	-0.35	-0.343	-5.655	0	
7	NewHse8	New Housing Supply	24 months	0.287	0.245	4.021	0	2.464

Multiple Linear Regression Equation =

"-1.219+0.552(10BondCurr)+0.352(NOM3)+1.177(Built$1)+6.585(GDPCurr)-0.038(Save1)-0.35(MRate3)+0.287(NewHse8)

The adequacy of the equations was reflected in the high "R²" readings (93.8%-97.2% range) and the significant t-values for each economic variable. The Durbin Watson Test (DW test) showed the residual error deviations are uncorrelated for all models. Whereas the coefficient (r) measured the correlation between the observed value and the predicted value, the B-value was computed to assess the strength of the relationship between each predictor variable to the criterion variable. Figure 4 and 5 presents the diagrams comparing the actual house prices index to the forecasting model's for the two residential property markets under the assessment:

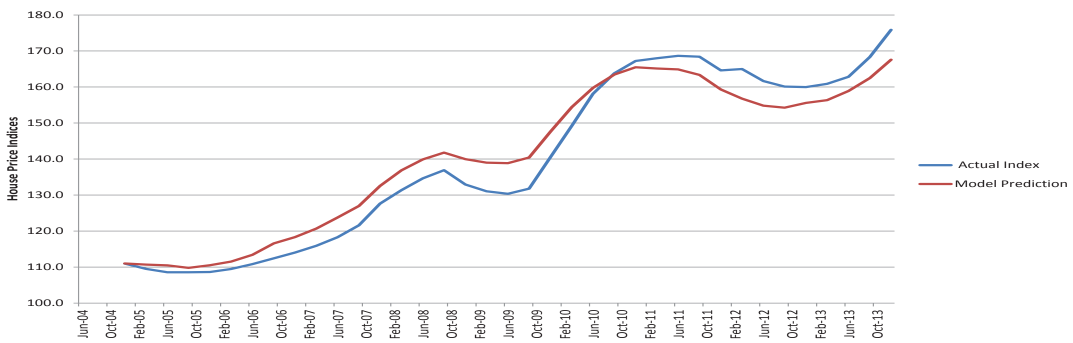

Figure 4: Melbourne Metropolitan – Forecasting Model Compared to Actual House Price Index

As per Figure 4, the forecasted house price index demonstrated similar trend as the actual index for the Melbourne Metropolitan market with a relatively lower elevation from December 2010 to December 2014. To further validate the regression equation, the forecast house prices were compared with the actual house prices of Melbourne Metropolitan for an extended 12 months subsequent to December 2014 in Table 2 as below:

Table 2 Extended 12 months Forecast – Melbourne Metropolitan

Period	Actual	Model Prediction	Difference
Dec-13	175.9	167.58	-4.72%
Mar-14	182.3	171.42	-5.99%
Jun-14	189.9	175.10	-7.81%
Sep-14	193.2	177.47	-8.16%
Dec-14	196.1	179.42	-8.48%

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The Model prediction derived a 7.07% growth in the 12 month period (from 167.58 to 179.42) and the actual index for house prices in Melbourne Metropolitan in 2014 showed 11.47% increase (175.90 to 196.10). As a result, there was a -8.48% difference in December 2014 comparing the actual index and forecasted index. This regression equation is considered moderately accurate with a single digit percentage difference (-8.48%) in forecasting the residential property market performance of Melbourne. Figure 5 below presents the diagrams comparing the actual house prices index to the forecasting model's for Clayton:

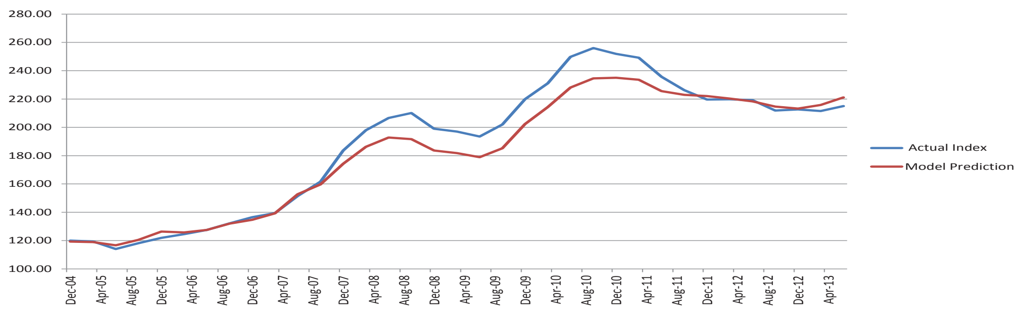

Figure 5 Clayton – Forecasting Model Compared to Actual House Price Index

Figure 5 shows accurate forecast in two intervals from December 2004 to December 2007 (before GFC 2008) and September 2011 to September 2013. To further validate the regression equation, the forecast house prices were compared with the actual house prices of Clayton for an extended 12 months subsequent to December 2014 in Table 3 as below:

Table 3 Extended 12 months Forecast – Melbourne Clayton

Period	Actual	Model Prediction	Difference
Jun-13	214.99	221.10	2.84%
Sep-13	230.16	234.90	2.06%
Dec-13	241.61	246.47	2.01%
Mar-14	257.29	250.41	-2.67%
Jun-14	266.99	259.77	-2.70%

The Model prediction derived a 17.49% growth in the 12 month period (from 221.10 to 259.77) and the actual index for house prices in Clayton showed larger 24.19% increase (175.90 to 196.10). There was a relatively smaller difference of -2.70% in June 2014 comparing the actual index and forecasted index. This regression equation is considered accurate producing a lessor than 5% percentage difference (-2.70%) forecasting model for the residential property market in Clayton.

Among the leading economic indicators, factors associated with foreign investment such as 10-year Government Bond Yields (10Bond), Foreign Currency Exchange (Forex) and Net Overseas Migration (NOM) emerged as leading components of the regression equations. According to Bowe (2012), Australia's second largest export was actually the Australian Commonwealth Government Bonds (ACGBs). As at June 2015, the Australian Office of Financial Management (AOFM, 2015) reported that approximately 65.2% of the

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Australian Government Securities (Treasury Bonds, Treasury Indexed Bonds, and Treasury Notes) were in the hands of foreign investors. Rich Asia Pacific investors are investing substantially into the Australia residential property market, both as foreigners and tourists, due to the renowned favourable living conditions and standards of education in Australia (Wong, Higgins and Wakefield, 2016). Net Overseas Migration (NOM) was one of the major traditional drivers of Melbourne residential property markets in this study and is consistent with various empirical studies (for example Benson, 2009, Borjas, 1994). The significant negatively correlated relationship between the Foreign Exchange Rate (Forex) is consistent with the overseas investment stratagem. Australian assets became more economically affordable when Australian currency was devalued against other foreign currencies. The foreign exchange factor is particularly relevant in terms of holding long terms assets such as properties from the investors' perspective.

6. CONCLUSION

The aim of this study is to explore evidences of a relationship between overseas investments and the Australian residential housing markets performance, particularly in areas that has experienced significant growth subsequent to GFC 2008. This research falls into this classification of a "predictive" design method whereby house prices in the selected suburbs will be forecasted to predict the future trend and validated using latest actual house prices data. Two statistical tests were applied to analyse the strength of the relationships between the dependent variables (House Prices) and independent variables (Australian Leading Economic Indicators) to confirm the validity of the model.

Both of the forecasting models have demonstrated a consistent pattern displaying the significant determinants for the respective residential property market performances. The factors associated with offshore investments have emerged significant and form part of major determinants among the traditional economic indicators. For example, 10-year Government Bond Yields, Foreign Currency Exchange and Net Overseas Migration were significantly correlated and emerged as leading components of the regression equations. They surpassed the importance of many other traditional residential market determinants such as rent growth, GDP per capital growth and net saving rates. As foreign investors keenly pursue an alternative asset class as part of their diversified portfolio, real estate had emerged as a crucial asset class alongside with ACGBs with similar investment trend observed. This study noted the emergence of private wealth in global real estate investment. As Asia Pacific nations and their citizens are getting more affluent and enjoying life styles previously deemed not possible, history repeats itself in that these affluent Asia Pacific citizens are now embracing the lifestyles previously exclusive to the rich western nations. One of the lifestyle trends is residential tourism.

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Current evaluation measures on Australian residential property market performance are perceived inadequate due to its performance evaluation being heavily focused on domestic conditions and drivers. As the world is becoming more transparent fuelled with globalisation and advancement in information technologies, these favourable drivers are fast acted upon by global real estate investors engaging in cross border real estate transactions in Australia. This research introduces a “Higgins & Peng” model to inclusively capture the global investments trend with “push factors” form part of the important evaluation platform. This research addresses the significance of FREI in Melbourne residential property market and provided a renewed platform for future valuation exercise and research conduct. Future studies on the related capitalist and non-capitalist drivers can shed crucial and meaningful insights on the Australian real estate market performance.

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LEADING THE WAY: PEER TO PEER MENTORING TO IMPROVE THE STUDENT EXPERIENCE AND ADAPTABILITY THROUGH CHANGE

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ABSTRACT

Peer to peer mentoring is well established in the literature as providing an effective mechanism to foster student's sense of belonging and to support their resilience and academic progress .This paper reports on a peer mentoring model that was established within a Built Environment School in 2015. The mentoring program was designed to provide peer mentoring support for Chinese students who were articulating into the third year of a Construction Management program delivered at a Melbourne university. The Chinese students had successfully completed two years of a Building Science program at the China University of Mining & Technology (CUMT). To support the Mentees to transition into year three of the Construction Management program three teaching academics from the Construction Management program partnered with their School's Academic Developer. The project team was formed to design and implement a mentoring program that sought to deliver reciprocal learning for local Melbourne based mentors and the newly arrived Chinese mentees. The program was designed to support Mentees to transition into the Construction Management program and living in Melbourne by providing study support and opportunities for social engagement. In this paper the authors reflect on their experiences of designing and implementing the peer mentoring program and report anecdotal evidence which suggests that peer to peer mentoring can provide an effective mechanism through which students are better prepared and supported to deal positively with the process of transition and the many complex challenges this can entail.

Keywords: Peer to Peer Mentoring; International Student experience; Reciprocal Learning

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INTRODUCTION

As Australia endeavours to sustain the growth of its international education industry, there have been major concerns regarding the experience of international students (Outhred and Chester, 2013). In addressing the many complex challenges facing universities and students, extensive research has shown the benefits of mentoring models, including peer mentoring, for higher education students (Collings, Swanson, and Watkins, 2016). Peer to peer mentoring is well established in the literature as a mechanism which delivers many benefits for both mentors and mentees. Its benefits are many and include academic support and social connectedness and student wellbeing, (Collings, Swanson, and Watkins, 2014). This paper reports on the initial anecdotal student evidence and the author's reflections of the impact of a peer mentoring program piloted in RMIT University's School of Property Construction and Project Management. This mentoring model, PCPM LEAD, was designed to support international student transition into the Built Environment discipline and to enhance student experience and wellbeing. The catalyst for the model was the influx of students from CUMT (China University of Mining & Technology) and the Beijing Normal University. Through a partnership with the School of Property Construction and Project Management (PCPM), students complete the final two years of undergraduate study within in either the Bachelor of Applied Science Construction Management or the Bachelor of Applied Science Property & Valuation programs.

This paper reports on the learning from the initial pilot phase and situates this learning in relation to key literature within the field. The authors identify particular dimensions of learning and impact which warrant further and deeper investigation. The model was designed to support this particular group of student's academic outcomes and progress, the model is also open more broadly to all international and local students in the School. PCPM third and fourth year students work as peer mentors and provide academic, social and transitional support for the mentees. The mentoring program is affiliated with the RMIT LEAD program and mentors receive recognition from the VC for participation in the program.

THE PCPM LEAD MENTORING PROGRAM: WHAT WE DID AND WHY

The PCPM LEAD mentoring model forms part of the RMIT LEAD program. RMIT LEAD is designed to foster co-curricular learning opportunities that allow students to: make a difference to individuals and communities; feel connected to the RMIT community; explore, test and fulfil their potential become creative, skilled, highly employable and purposeful graduates. Within the School of PCPM, it was identified that a mentoring program could provide the opportunity to support the transitional needs of the

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newly arrived CUMT and Beijing Normal University students, along with the broader student community.

The mentoring program was designed and supported by four academic staff: one Australian born Academic Developer who is qualified in ESL and whose role is to support learning and teaching within the School; two Australian born educators who have rich teaching experiences in the designated programs both in Australia and in Singapore and Hong Kong; and one Chinese born educator who grew up and studied in China, and has worked in Australia for more than six years. All staff acted as the academic champions within the program. The mixed backgrounds and specialisations in this team provided a unique knowledge set for international students’ needs. Figure 1 shows the LEAD mentoring model which will be further explained in the following subsections.

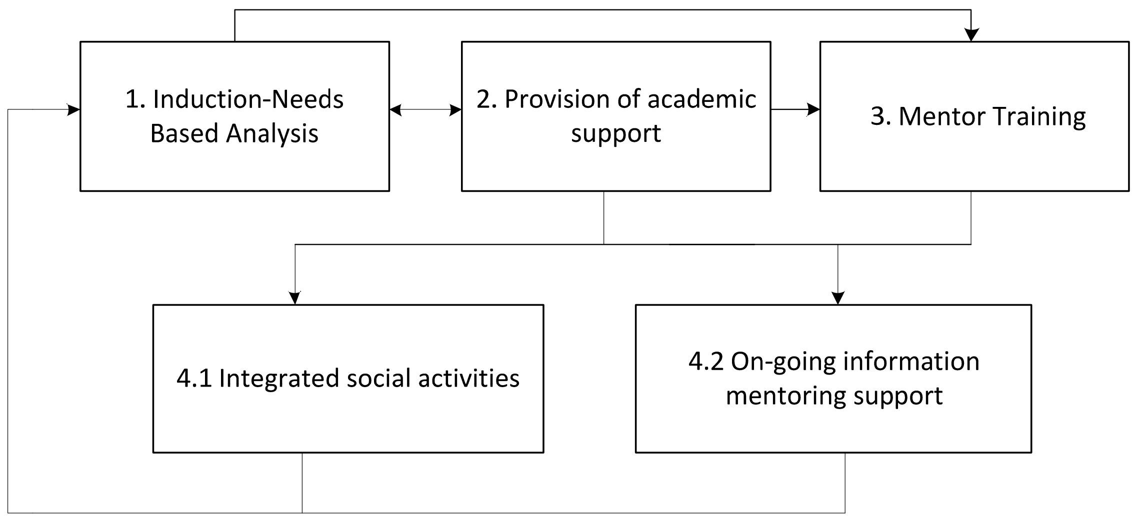

Figure 1: PCPM LEAD Mentoring Model

Program design

The PCPM LEAD mentoring team developed the initial program to best suit the needs of the mentees by drawing on their local and international teaching experience. Volunteer mentors were recruited from years three and four of their undergraduate program. The mentors included a mix from the Construction Management, Property and Valuation and Project Management disciplines. All mentors were required to complete five hours of mentor training which included a focus on attributes of the mentor, the boundaries between the role of the mentor versus teacher, skills and strategies to facilitate learning through working with peers, inter cultural communication, relationship building and understanding different learning styles. In addition to their training, mentors were required to contribute a minimum of fifteen hours mentoring for each semester.

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The PCPM mentoring leadership team had two objectives: (1) to assist students to transition into their new social and academic environment; (2) to ensure students were supported to develop the academic literacies to be able to achieve success; (3) to optimise opportunities for the mentees to build relationships within their cohort, and with their PCPM mentors. The program was also designed to facilitate deeper relationships with the authors, three of whom were teaching into the program. This approach drew on the existing literature which validates peer to peer mentoring as a highly effective mechanism through which students can support their peers and importantly learn from one another (Christie, 2014). As such, the developed PCPM LEAD mentoring model is underpinned by the core principles of reciprocity, recognition that mentoring programs delivers beneficial learning outcomes for both mentors and mentees, and voluntary student engagement (Collings et al., 2016).

Upon their arrival in the School of PCPM CUMT and Beijing Normal University students (mentees) were briefed about the mentoring program and encouraged to participate. Working as School champions, the authors developed and nurtured in and out of class relationships with the mentees students and devised a program to support their academic and social engagement. Further, the program was designed so that was to across the mentors and mentees so that students would initiate further contact themselves and interact more informally.

Program Activities

The activities developed by the LEAD mentoring team varied slightly across 2015 and 2016. In 2015 PCPM LEAD mentors worked in class with the teacher in a common third year Research Methods course and participated in fortnightly 'Study Buddy' Drop in sessions. The objectives of these activities were to assist in the transition in teaching and learning styles between the western and non-Western education methods, and the different disciplinary content. Further, the Mentees have studied a "Building services" program in China which is embedded with calculations, designs and exams; while the current program in Australia is management-oriented requiring comprehensive understanding about the construction industry operation, and strong text based academic skills on essay and report writing. The diversity of these activities provided a formal and informal mentoring experience, allowing for different student needs to be addressed. Additionally, social events which included cooking and bowling were held. The objective of these events was to assist in the transition to new socio cultural environments experienced by the mentees. This included language and cultural issues which present major hurdles to the development of new friendships. In 2016, Study Buddy Drop in sessions and social events were run which included cooking and bowling and a day trip to a wildlife sanctuary were held with the same objectives.

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REFLECTIONS ON PRACTICE AND THE ROLE OF CONVERSATION

In reflecting on our practice, the development and leadership of the PCPM Mentoring Model we draw upon Haigh's (2006) concept that our conversations play a formative role in fostering our understandings. As Haigh identifies this involves making explicit our tacit understandings of the particular phenomena. By engaging in an on-going dialogue about our experiences as we developed and implemented the mentoring model we shared our perceptions of the efficacy of the model, the challenges we faced and the observed benefits the model delivered for our students.

Senge (1994) developed the term 'learningful conversation" to describe conversations which foster learning about practice. Our conversations as "learningful' fostered learning to evoke our critical reflections on practice. Our reflections encompassed a focus on what Senge refers to as "the mental models that are a foundation for personal action". As Senge (1990) describes, these mental models, "are deeply ingrained assumptions, generalizations, or even pictures or images that influence how we understand the world and how we take action" (Senge, 1990, p. 8).

We held a schedule of meetings throughout each semester for the purpose of sharing and debriefing about the on the ground experiences and needs of the mentees and mentors so that the program could be refined/adapted as required. These meetings were also critical in facilitating the exchange of the author's goals and aspirations, and in further developing our understandings of students needs and of how best to support them. Our conversations were critical to ensuring that our approach was collaborative: with an ethos of collegiate collaboration pivotal in our work. Our conversations were also critical to ensuring that we optimised the learning outcomes for all students. In this way we adopted an action learning cycle of plan, act and reflect to inform future practice.

OUR OBSERVATIONS OF THE STUDENT EXPERIENCE

Mentees

In our many discussions about the needs and progress of the mentees the authors noted that issues of isolation and intercultural communication represented key challenges. Adjusting to Western ways of knowing and student centred active learning pedagogies also presented key challenges. Text based assessments were also challenging for students as they were required to adopt a linear approach to these assessments, (such as reports, analyses, research).

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Added to the academic needs of students was their need to develop a sense of belonging and to build a connection with the local students. Transitioning into living in Melbourne also represented a key challenge.

In our conversations with the mentees what we learnt was that they perceived and experienced was that the mentoring program helped to:

- Foster a sense of belonging in the School
- Support their learning and academic literacies
- Enable understandings the nature and role of Construction Management in the Australian context
- Identify with their mentors as peers
- Feel safe in terms of seeking help
- Understand Australian culture through interactions with locals and longer term resident international students
- Understand different ways of learning and working such as group work

Students also identified that they would benefit from preparatory lessons in each subject area to assist with learning, session on study tips and services and supports at RMIT.

Mentors

Conversations with the mentors students identified that they perceived that participation in the mentoring program enhanced their professional practice skills such as professional communication, time management, inter cultural communication, leadership, and organisational capabilities. Mentors also expressed that their participation in the program fostered their own sense of belonging within the School and broader university. One of the goals of the program was to foster a reciprocal exchange between the two groups of students about Construction Management. This did not arise as an outcome, and warrants further investigation.

Mentors also expressed the view that participating in the program enabled them to feel that they were giving something back to the School, and that working with the mentees enabled a deeper understanding of the transitional needs of international students.

Some mentors in the program were international students who expressed that they wanted to support the mentees as they had faced their own significant challenges and were mindful of the need for targeted transitional support.

OUR REFLECTIONS ON PRACTICE

Leadership of the mentoring program can be described as taking three different foci: Coordination, Teaching and Social. Coordination activities involved scheduling mentee meetings, scheduling academic study ‘drop-in’ sessions and planning of social activities. Such coordination activity

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revolved around meetings across the PCPM LEAD team which were held throughout the twelve week teaching period. In 2015 teaching related support activity involved the formulation of in-class activities which could involve LEAD mentors working with mentees, as well as other students. These activities sought to build the course related capabilities of Mentees as well as providing leadership opportunities for LEAD students. Other, less formal course related activity involved the supervision of 'drop-in' sessions whereby LEAD mentors could provide ongoing and needs based learning support to the mentees. This support included course queries and addressing challenges in utilising learning resources, such as Blackboard. Lastly, the PCPM leadership team were also involved in planned social activities such as cooking, lawn bowls and visits to local attractions. In this context, the leadership team acted more as facilitators of social interaction rather than as teachers. In all, staff participation in the program involved a wide range of interaction ranging from the formal to the informal, across a variety of settings and contexts.

Initial formation of the staff leadership group and coordination of program activities was undertaken in a collaborative mode. Decisions were taken based upon consultation arrived at by consensus. Decisions were generally taken at meetings which were arranged by the first author who was also program lead. The voluntary nature of staff participation helped in this regard as commitment to program goals was strong across the group.

Course related program activities provided a range of experiences for the leadership team. In transitioning to Construction Management in the Australian context and the PCPM learning environment, it was acknowledged that mentees would experience differences in the teaching and learning styles utilised in the Australian Higher Education context as compared to those used in their country of birth. To provide academic support in 2015 LEAD mentors were invited into a portion of the class to assist mentees (and other students) to complete an in-class exercise. These exercises needed to be carefully designed so as to leverage the discipline knowledge and capabilities of LEAD mentors as well as providing useful guidance to Mentees. Such in class mentoring limited scope for mentor involvement as it generally required that LEAD mentors had previously completed the course in which the Mentees were being guided. Upon reflection, the in-class approach achieved a mix of results. It provided useful mentoring for both mentees and the wider class cohort. It also highlighted the importance of clarifying the role and remit of the mentors so that they were not perceived as a supplement to the teacher.

Greater success was achieved through coordinated 'drop-in' sessions at which LEAD mentors were rostered to attend at a scheduled location on a fortnightly basis. Times and locations were advertised to the wider student group and reinforced via further email to Mentees. In general these sessions were well attended by Mentees and sometimes by other

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students. LEAD mentors were able to provide advice across a range of course topics, supported by one of the authors who could oversee the interaction and interject in areas of uncertainty. This more informal form of interaction was seen as useful for participating students who tended to view the LEAD mentors as offering 'best intent' advice rather than formally sanctioned advice when participating in the classroom context, described above. This more informal and inclusive environment seemed more useful in providing transitional support for Mentees who proactively sought it out. Obviously, those who did not attend these sessions did not receive this benefit (as opposed to the classroom model which accessed most, if not all, of the mentees).

Although social activities did not link directly to course related learning outcomes, they seemed to provide strong benefits to both the LEAD mentors and mentees. The compounding cultural challenges experienced by many mentees in the classroom have potential to detrimentally affect the student experience, particularly when the overall course environment is considered. In general, transitioning Mentees were provided with course exemptions for subjects that had previously completed, which tended to involve technical/mathematical competency. This left subjects that mainly related to language, argument and qualitative inquiry, subjects which present an additional challenge when undertaken in a second language. It was not so much these subjects represented a language challenge, rather that they reflected an imbalanced program which would typically involve a more even mix of qualitative and quantitative approaches. Within this environment student confidence in their new environment is arguably under challenge, making success in other fields such as social life particularly important.

Planned social activities such as lawn bowls at the Fitzroy Bowling Club and a cooking class at a staff members home helped provided a valuable social experience that enabled a two way cultural exchange, but more importantly reminded students that there is more to life than just what happens in the classroom. For Mentees this experience helped place their in-class experience within the wider context of their international experience. Importantly the social activities undertaken employed a structured component which helped get students talking and sharing in a non-threating way. Preparing a meal involving a mix of Chinese and local dishes was a particularly successful activity as it seemed to deliver an interactive, confidence-building social activity, while at the same time relieving students of the pressure to sustain social interaction entirely on their own. While not an impediment for the authors, clearly these activities involve a commitment to undertaking program activities outside of the campus environment.

In carrying out the program activities described above, it was particularly useful to have a member of the leadership team from Chinese heritage involved. This involvement enabled communication between the

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remaining authors and mentee group to be enhanced, particularly through the use of social media applications like WeChat. Discussion between the Chinese born author and mentees also provided an authentic perspective which resonated with students who could relate to shared experiences of the Australian culture. Deeper awareness of issues such as cultural impediments to asking lecturers for clarification was gained. The drop in sessions were critical to fostering these inter cultural understandings.

A final observation and reflection related to mentee's perceptions of life post-graduation. For many mentees, initial expectations of life after graduation involved undertaking postgraduate study, usually a Masters degree. Mentees started shifting their goals toward achieving industry-related part-time work in the later years of study. This aspect was largely unanticipated by the Construction Management program and provides an opportunity for further program development in subsequent years. Such program development may involve the inclusion of some kind of industry relevant experience for mentees and LEAD mentors.

WHERE TO FROM HERE?

Further research will build on this initial pilot phase. Future research will capture and evaluate post participant data to be captured during 2017 and 2018 with the aim to systematically explore the impact of participating in the mentoring program for mentees and mentors. Future examination of the student experience includes an exploration of the transitional, social and academic benefits of the program for mentees and whether the program develops professional practice attributes for mentors. By building on this study further research is well positioned to contribute to knowledge of how to best serve the needs of transitioning international students and to also deepen understandings of the impact of mentoring on the student experience in higher education (for both mentees and mentors). Future evaluation of mentor's experiences of the model is closely aligned with RMIT's strategic focus on employability. For mentees, the literature documents many benefits which include to support transition into higher education, foster student belonging and support students to work across academic literacies (Christie, 2014). Although mentoring is conceptualised as a mutually beneficial relationship there is comparatively less understanding of mentors' experiences (Haggard, Dougherty, Turban, and Wilbanks, 2011), including outcomes for university student mentors (Hughes, Boyd, & Dykstra, 2010). By also examining the mentor's experiences further research will contribute to this gap in the literature.

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CONCLUSIONS

This paper has provided some insights into the complex nature of the challenges transitioning international students can experience and how models of voluntary peer mentoring can support student well-being and assist in enhancing and optimising the student learning experience. As discussed, the academic and social needs for transitioning international students are complex and challenging. This is particularly so in the current mass education system in higher education.

Our paper has highlighted the need to systemically investigate models of peer mentoring in higher education in ways which focus on the learning and impact for both mentors and mentees. We have begun here to contribute to the literature which examines how to optimise support provided for the transitional, social and academic needs of the international cohort. Our reflections on practice highlight the need for our on-going and expanded research and the importance of sharing and deepening knowledge through the 'learningful conversations".

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INCLUSION AND WELLBEING FOR PEOPLE WITH AUTISM AND THE ROLE OF BUILT ENVIRONMENT

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ABSTRACT

Autism Spectrum Conditions are neurological disorders which make inclusion in society very difficult for the affected individuals. The main challenges that people with autism face are related to sensory processing disorders, communication difficulties and restricted repetitive patterns of behaviour. Current methods for integrating people with autism focus primarily on equipping autistic individuals with the tools to tolerate circumstances that they might find uncomfortable in social day-to-day situations. The society’s response to accommodating the condition is usually restricted to improving access to selected spaces which often have limited functionality and give the autistic narrow margins for physical and intellectual development. The paper shows the preliminary results of a qualitative meta-analysis of the extant literature relating to societal aspects that need to be taken into account when considering the integration of people with autism. Also, employing the same methodology, the study explores the way in which built environment can have a contribution to the integration of people with autism and the degree to which inclusive physical space represents a positive factor to an autistic individual’s subjective wellbeing and quality of life.

Keywords: autism, built environment, inclusion, integration

INTRODUCTION

The act of integrating non-typical individuals into the current structure of society involves both internal measures to alleviate the impact of disability and external circumstances that help people interact with the outside world. The later can only be achieved through two means: the adaptation of human behaviour to accommodate the needs of non-typical individuals and the adaptation of environments which favour the conditions of disabled people. Integration into society should not be the ultimate goal without establishing that achieving or increasing it has a beneficial effect on the wellbeing and quality of life (QoL) of people with disabilities. The aim of this paper is to determine the effect of an intervention to the built environment on people with autism from a

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wellbeing/QoL and integration point of view. As a result, wellbeing and integration become benchmarks for assessing the performance of such built environment intervention. The question that this study aims to answer is if, how and to what degree does built environment have the potential to increase wellbeing/QoL and integration of people with autism.

METHODOLOGY

The study presents the preliminary results of a meta-analysis on the current literature regarding the state of integration and wellbeing/QoL for people with disabilities and, in particular, people with autism. The number of studies included is limited by the preliminary form of this analysis and space constraints. The computer database Google Scholar was initially searched using different combinations of the keywords: autism, integration, disability, stigma, access, legislation, quality of life and wellbeing. Sources were also gathered through snowball sampling where suitable cited references from the initial sources were used. Papers discussing integration and wellbeing for people with autism were mainly focused on, however, when aspects overlapped, the investigation took a more general approach concentrating on all people with disabilities. The total number of 21 papers were classified into three categories in relation to the presented topic: integration and QoL/wellbeing of people with disabilities or autism. The date of publication did not represent a selection criteria, however, in the present text, focus was put on more recent publications. The study employs qualitative research methodologies to conduct an inquiry of the literature on the elements contributing to the integration of non-typical individuals. These aspects are separated into two categories: societal standards that are aiming towards the inclusion of non-typical individuals (integration enablers) and standards that restrict this process (integration barriers). Careful consideration is put on elements that facilitate or come against integration of people with autism and other cognitive disabilities where the disruptive nature of the disorder can cause different reactions from the public in comparison to other disabilities. For each aspect contributing to integration, an assessment on the influence of built environment is made as presenting a positive, negative or not applicable input towards inclusion.

Integration should be viewed as a means to an end and not an end in itself since individual outcome should possess more value to a person than current plans for an inclusive society. Therefore, the study analyses literature on wellbeing and QoL as different standards of human development for people with autism and assesses the capacity of integration to make an improvement on these benchmarks. QoL for people with autism is examined through several assessment tools. Built environment is analysed as having a positive, negative or not applicable input to the QoL of the autistic individual from four perspectives: psychological, physical, social and educational/work related. The potential

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of built environment to affect wellbeing for people with autism is analysed in the same way through three philosophical approaches: hedonistic, desire fulfilment and capabilitarian.

INTEGRATION OF PEOPLE WITH AUTISM

In order to achieve significant integration results, autistic persons need to be prepared to cope with the present and near future expectations from society. However, integration should not be viewed from just one side. Not only is a civilized society's duty to take care of its members but not doing so will trigger immense social and economic burdens on family members and can have a detrimental effect on society at large. Society has developed two distinct ways to help people with disabilities integrate: alleviate or remedy a person's disability through scientific discoveries or reorganise the social and environmental structure in order to make accessible to the disabled as many experiences as possible. The barriers to integration in society for people with disabilities have multiple dimensions, but they mostly revolve around the lack of resources and society's perception of people with disabilities.

Integration Barriers			
Type	**Description**	**Role of BE**	**Source**
Income Handicap	Lower chances of employment and lower work efficiency caused by disability	Positive	Sen 2004
Conversion Handicap	Lower capacity to transform currency into services due to a disability	Positive	Sen 2004
Over positive bias	Viewing disabled individuals as more valuable or capable	N/A	Crow 2000
Stigma	Viewing disabled individuals as less capable or valuable	N/A	Barg et al 2010; Trammell 2009
Lack of Access	Restricted capacity to take part in activities due to non-typical development	Positive	Imrie and Kumar 1998; Cahill and Eggleston 1995
Resources	Limited time, financial and material support for people with disabilities	Negative	Knapp et al 2009; Ganz 2007
Integration Enablers			
Non Discrimination			
Legislation	Insuring equal opportunities and treatment for non-typical individuals	N/A	Australian Human Rights Commission 2012
Shifting social attitudes	Encouraging positive attitudes towards non-typical individuals	N/A	Daruwalla and Darcy 2005
Awareness	Informing the public about non-typical individuals in order to remove stigma and encourage healthy interactions	N/A	Dillenburger et al 2013
Facilitation of people with disabilities to limit the impact of disability			
Financial support	Minimising the financial gap and conversion between typical and non-typical individuals	N/A	Ganz 2007; Greco et al 2005
Healthcare	Insuring the access to medical help catered to non-typical individuals	N/A	Oswald and Sonenklar 2007
Research and medical progress	Advancing knowledge on the conditions of non-typical individuals and discovering ways to remedy disabilities	N/A	Anagnostou et al 2014
Education	Improve teaching capacities for people with disabilities	Positive	Khare and Mullick 2009; Mostafa 2008
Guarantee of access to participation in every area of life			
Sensory spaces	Encourage the implementation of sensory comfortable spaces for people with autism	Positive	American Psychiatric Association 2013; Mostafa 2008
Identifiable spaces	Implementing markers that make spaces easily identifiable	Positive	Klinger and Dawson 2001

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Current societal structures are catered to and present the highest efficiency for typical individuals because they define the characteristics displayed in the largest number of people. Heavy costs are sustained by both private and public sector to support the care for people with disabilities (Snook and Webster, 1987), especially for a large number autistic individuals how require care their entire lives (Ganz, 2007; Knapp et al, 2009). The actions needed to remove social and educational barriers for people with autism can be regarded as measures that require low amounts of resources since they can be adjusted on a local level. Regarding built environment, however, the efforts become much larger because access needs to be insured for as many environments as possible in order to allow people to engage with activities and achieve optimal levels of personal and professional development. The problem becomes even more important when considering the amount of sensory feed-back we receive and rely on from our built environment and the sensory processing disorders that people with autism possess. However, once built environment is used in favour of disabled people it provides an essential tool for integration because it provides access and enables people to take advantage of the physical space without special care (Cahill and Eggleston, 1995; Imrie and Kumar, 1998).

Regarding financial gains, Amartya Sen (2004) argues that even if a person with disabilities earns similar incomes as a typical individual, he or she cannot convert that revenue into the same products and experiences because generally those services need to be catered to his or her particular needs, costing a lot more than it is commonly practiced (Sen, 2004, Nussbaum, 2006). He refers to this aspect as "conversion handicap" which is different from "income handicap" identified as the circumstance where people with disabilities find it harder to find and maintain jobs which will inevitably impact their earnings (Sen, 2004). When referring to people with autism, the "conversion handicap" can manifest in different ways and can have a highly variable impact due to the large dissimilarities between autistic individuals.

In her writings, Jones (2011) points out that there are three dimensions of inclusion that must be fulfilled in order for people with disabilities to be incorporated in society: "a non-discriminatory attitude towards people with disabilities; the guarantee of access to participation in every area of life; and the facilitation of people with disabilities to limit the impact of disability" (Jones, 2011). To a large degree, western societies have had good results in establishing a non-discriminatory attitude towards people with disabilities. Regulations have been put in place to disrupt discrimination and encourage integration for disabled individuals (Australian Human Rights Commission, 2012). The awareness brought by information about people with disabilities translate into useful tools that typical individuals use to accommodate non-typical individuals (Dillenburger et al, 2013) as well as in a shift in attitudes which transform disabled people from tolerated members into contributing members of the

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society (Daruwalla and Darcy, 2005). However, even in the world's most progressive societies, a barrier to integration is bias against people with disabilities. This can be achieved both through self-stigmatization or from stigmatization by the general public. Studies show that people with autism and their caregivers face more severe stigma due to disruptive behaviours caused by autism (Trammell, 2009; Barg et al, 2010). On the other hand, people with disabilities can be viewed as outsiders through positive biases or biases of low expectations (Crow, 2000). Because the costs of living with a disability are higher in almost all aspects of life in comparison to typical individuals, society needs to provide people with disabilities with the financial support that will allow them to develop to their full potential (Greco et al, 2005; Oswald and Sonenklar, 2007).

The end goal should be the complete remedy of disabilities or alleviation of the symptoms through research (Anagnostou et al, 2014), because it would provide people the access to experience things outside the concrete structures that humans have developed over time. Integration into society also means having the skills to approach activities that typical individuals can easily acquire. For this to happen, different education methods need to be explored and established in order to cater to the needs of non-typical individuals (Khare and Mullick, 2009).

The guarantee of access to participation in every area of life takes inclusion a step forward from the non-discriminatory attitude towards people with disabilities and transforms them from tolerable members into participatory members of the society. The inclusion of people with disabilities in all areas of life has two layers: the physical implementation of environments that would limit the impact of disability and training typical individuals in understanding the disabilities and challenges that people with disability face. The second aspect is particularly important for people with cognitive disorders where typical individuals are a lot less likely to identify and make proper judgments on how to approach and interact with people with disabilities. Because autistic individuals possess sensory processing disorders (Mostafa, 2008; American Psychiatric Association, 2013) as well as deficiencies in prototype formation and generalization issues (Klinger and Dawson, 2001), the built environment has a much larger influence on their potential to navigate and interact in present day to day circumstances.

THE OUTCOME OF PEOPLE WITH AUTISM – WELLBEING AND QOL

QoL and wellbeing are both benchmarks for the condition of an individual in regard to their social, economic, physical, psychological and spiritual state. However, the difference between these two terms refers to the point of view from which the characteristics are seen. Wellbeing represents an individual's condition in relation to his own ideals, whereas

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QoL relates to a person's standards and to society's norm of what a perfect outcome would look like.

Quality of Life			
Type	**Description**	**Role of BE**	**Source**
Physical	Levels of bodily health, comfort, autonomy	N/A	van Heijst 2013
Social	Capacity for interpersonal activities	Positive	van Heijst 2013
Education/ work	Potential to pursue, acquire and engage in activities that require skill development	Positive	van Heijst 2013
Psychological	Ability to feel safe, engage and experience feelings, thoughts and beliefs	Positive	van Heijst 2013
Wellbeing			
Pleasure fulfilment	Presence of pleasure and absence of pain	Positive	Parfit 1984
Desire fulfilment	Ability to fulfil one's desires	Positive	Parfit 1984
Capabilitarian	Capacity to engage in activities that one might find valuable	Positive	Sen 2004; Robeyns, 2016; Parfit 1984

Establishing the QoL for people with autism can be done through proxy reported or self-reported questionnaires. Research reveals that in many cases, people with autism can assess their QoL in a valid and reliable manner, even during their childhood (Shipman et al, 2011). Similar to typical developing individuals, children with autism report better QoL in comparison to their proxy reported QoL assessment. The difference comes especially when considering the non-observable aspects such as emotional, spiritual and social elements which tend to be estimated from higher standards by the caregivers of younger people (van Heijst, 2013). Also, because of their social and communication disorders, there can be expected even higher discrepancy levels between self-reported and proxy reported QoL. However, in almost all circumstances, people with autism have been found to show lower levels of QoL in comparison to people without autism in a few key areas such as relationships, leisure and social activities (van Heijst, 2013). The influence of built environment in increasing QoL for people with autism is hard to determine. However, the evidence suggests that comfortable surroundings lower the sensory burden (Mostafa, 2008) which would facilitate the accessibility to social spaces. Also, it is reasonable to assume that if lower sensory stimulus determines an increase in learning performance, it would also provide better surroundings for social interaction.

Considering the QoL assessment tools available, the question still remains to whether inclusion in all levels of society would increase the QoL scores for people with autism. As inclusion implies a high likelihood of social interaction, it is easy to assume that integration in all levels of society would determine higher opportunities to engage in meaningful relationships with peers. Also, having a non-discriminatory approach and insuring access will determine a rise in the number of leisure activities in which people with autism can get involved in order to enrich the experiences they have in their social relationships. By providing autistic people with tools that limit the impact of their condition, they will have more resources and higher capacities to pursue the activities that they

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value. Therefore, inclusion can be used as a reliable instrument for improving the QoL for autistic individuals. Also, it represents a safe approach since it does not force them into actions that people in general consider to boost wellbeing, but rather offers them more opportunities to engage with activities and people that they value.

In terms of what society more rigidly considers to represent a good individual outcome and QoL, studies show that there are three factors that would considerably add to the success of a person with autism: early language development, a higher intelligence coefficient, above 70 (Howlin et al, 2004; van Heijst, 2013) and less severe autistic symptoms (Eaves and Ho, 2008; Kuhlthau et al, 2010). These three aspects should not be considered separately, but rather as a matrix where each one is dependent on the other. Studies show that language development has a strong influence on autistic people's cognitive progress especially in the early years (Mawhood et al, 2000). Having less severe autism symptoms would allow the autistic child to engage in more diverse activities for a longer period of time which would boost his information intake and improve his cognitive abilities (Mostafa, 2008). Therefore, achieving a better outcome would definitely be influenced by lowering the impact of autism symptoms by addressing the sensory processing disorders which in turn will have a beneficial influence on language development and cognitive abilities.

Wellbeing is a more complex issue to analyse when considering the fact that it is a subjective measure, different from person to person and almost impossible to clearly establish with reliable tools. As a result, determining whether inclusion is society through built environment would have a beneficial effect for people with autism can become a difficult task.

The hedonistic theory of wellbeing considers that fulfilment and happiness comes from the simple presence of pleasure and absence of pain (Parfit, 1984). Although at a first glance these aspects seem to hold true for most of people's perceptions, the theory comes to scrutiny when it is recognized that many feelings that people hold valuable and necessary come as painful experiences, such as longing or wishful thinking. The same can be said about the desire fulfilment theory where it is impossible to establish a general trend of achievements that all people value (Parfit, 1984). The objective list theory of wellbeing is not without its flaws, but it is probably the most appropriate approach when considering the fulfilment and happiness of people with disabilities. It focuses on the assumption that certain functionings, that people have reason to value, must be insured in order for them to be able to have the necessary tools to achieve wellbeing (Parfit, 1984; Robeyns, 2016). Because it refers to a list of aspects that humans have reason to value, the objective list approach provides a far more reliable benchmark for assessing people's wellbeing since it is judged within the same parameters. However, for this to become a subjective measure, unlike QoL criteria, the focus must

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mainly be put on the capability of a person to do something, rather than the achievement itself. This also gives people the option to decide for themselves how their lives should look like with no rigid limiting factors from society.

CONCLUSION

Because it can provide people with autism with comfortable circumstances to conduct social, leisure and intellectual activities, built environment has a great potential to become an important tool in increasing the outcome of people with autism. Evidence shows that built environment has a larger impact on QoL/wellbeing than on integration because it can specifically address the individual's needs, rather than the requirements of a larger group. Also, in terms of wellbeing/QoL for people with autism, built environment becomes an essential tool due to the enormous beneficial impact that a comfortable sensory environment can provide. The physical QoL of people with autism is the least impacted by built environment since it may facilitate, but cannot fully address the bodily functions and internal physical comfort of an individual. Regarding psychological, social and educational/work related QoL, appropriate built environment has a much larger beneficial impact due to its capacity to produce less stress and increase focus on tasks or social/leisure activities. Social and educational/work related QoL are positively influenced by psychological QoL which provides autistic individuals with the necessary state of mind to conduct activities.

An appropriate built environment can have a beneficial effect on the wellbeing of people with autism especially considering the hedonistic approach where painful experiences caused by uncomfortable surroundings are seen as undesirable. In regard to the other two philosophical approaches to wellbeing, built environment can have a beneficial effect because it can offer people with autism the pathway to take advantage of the activities that are made available to them.

In regard to inclusion in society, built environment cannot determine successful results due to the many aspects that need to be met in order for integration to happen. However, because it is the main variable for insuring accessibility, built environment is essential when considering integration for people with autism, due to the sensory and generalization issues that are prevalent in autism. The biggest impact that built environment has on the integration of people with autism relates to its ability to provide access and suitable surroundings for individuals to engage in actions that benefit their development, such as education, work, social and leisure activities. As a result, the environment determines an indirect beneficial impact on autistic people's ability to gain skills and resources, which allow them to pursue their personal goals. The largest barrier to integration is the limited amount of resources that can

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be allocated for transforming built environment into a comfortable living ground for people with disabilities. The lack of labour participation represents one of the biggest costs that society pays for a non-inclusive environment. However, because the requirements of people with disabilities are so diverse and demand extensive modifications to the current structure, society is in a continuous struggle for resources that advance inclusivity, but still offer a fair benefit for typical individuals.

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FOSTERING STUDENT WORK READINESS – A UNIVERSITY CASE STUDY

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ABSTRACT

Student work readiness relates to the acquisition of relevant skills and knowledge which enable students to make meaningful contributions to industry, and assist them in their transition from student to practitioner. An individual's smooth transition into the workforce translates into higher levels of interactions in their workplace, ensuing in benefits for both the employee and the employer. In the built environment, employees are known to experience high levels of work-related stress, exacerbating the need for built environment professionals to be well prepared for the workforce. While work readiness is typically reserved for graduates who have completed their program of study, there has been a notable increase in built environment undergraduates combining work and study prior to graduation. This trend challenges universities to consider that these students need to be work ready prior to completion of their studies. Research notes that student work readiness can be attained through collaboration between universities, students and industry. This study uses the newly conceptualised work readiness model, known as The Life Buoy model, to explore the ways in which one Australian university collaborates with industry to i.) foster the development of work ready characteristics in built environment students; and, ii.) apply university-based initiatives to underpin the development of work ready characteristics. Analysis of course-related documents classified work readiness initiatives at the university into the eight components of the Life Buoy model, suggesting that it may be a useful framework to guide universities to better work with industry in designing and assessing their work ready initiatives.

Keywords: built environment, industry involvement, student perspective, university initiatives, work readiness.

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INTRODUCTION

Work readiness as an industry wide objective

Work readiness is a graduate attribute that is typically used in reference to graduates who have completed their studies and have commenced their professional career in industry. Literature has been found to describe work readiness as a concept with different labels, including: work preparedness, graduate employability, transferable skills, key competencies, and generic attributes (Nettleton, Litchfield & Taylor, 2008; Caballero & Walker, 2010). Work readiness has been identified as an area of escalating interest to employers world-wide. Furthermore, with reference to the changing nature of the workplace, research has identified that "the extent to which graduates are 'work ready' is seen as indicative of their potential in terms of job performance and career advancement" (Caballero & Walker, 2010: 13). Thus, preparing work ready graduates can be seen as an industry wide objective. Furthermore, a smooth transition into the work environment is interrelated with higher levels of interaction, mutual support in the workplace, and a significant reduction in staff turnover (Argyle, 1989). A work ready individual is one that is equipped to make a successful transition into the workforce, thus is able to make a positive contribution to his/her new organisation, employer and industry at large.

Work readiness in the context of the built environment

While work readiness is typically reserved for students who have successfully completed their program of study and are entering the workforce, studies indicate that students in the built environment are combining work and study (Curtis & Williams, 2002). Studies have found that hours and effort spent by undergraduate built environment students in paid employment were at the very least, as long as the hours spent at university (Forsythe and Zou, 2006; Lingard, 2005). Combining work and study comes with inherent benefits for students; students who combine work and study have been found to develop transferable employability skills including organisational, interpersonal and time management skills (Watts & Pickering, 2000). However, these findings that show more students are combining work and study, challenge the understanding that work readiness is a concept to be reserved for graduates, as the work readiness requirements of this emerging student cohort who combine work and study need to be catered to prior to graduation. The student cohort undertaking paid work while completing their degree presents a new challenge for universities; these students call for work readiness prior to graduation. Savage, Davis and Miller (2010:103) found that "university plays a crucial role in ensuring graduates develop lifelong learning skills and attributes that can carry them onto a long and fruitful career, however, professionals and students did not feel universities were doing enough to ensure this development occurred". While universities are recognised as having a primary role in fostering work readiness in

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graduates, it has been debated whether the educational institutions are the principal places for students to gain employability skills (Cranmer, 2006).

Universities: Trying to foster work readiness in students

The call for work ready graduates is felt globally. In Australia, the rates of graduates finding employment are relatively high at 75% and above, yet studies highlight that employers are not satisfied with aspects of student work readiness. Employers advocate for the integration of practical skill development into university programs, believing that a closer alignment between graduate work readiness and desired employability skills would ensue as a result (Cavanagh, Burstone & Southcombe, 2015). This concern that university programs are not producing work ready graduates is not a new concept and one that is not merely confined to Australia. In their research seventeen years ago, De la Harpe, Radloff and Wyber (2000) suggested that there is concern world-wide that students are graduating from their university programmes without the skills necessary for their future careers. This highlights an existing discrepancy between the definition and understanding of the concept of work readiness from academic and industry perspectives, placing the students in a position where the skills taught to them at university to prepare them for the workforce are not in alignment with the demands of their employers in the respective industry.

Cranmer (2006) argued that universities may not be the prime places for stimulating graduate employability, and highlighted that universities and academics need to accurately decipher the demands of the labour market. It has been recommended that universities should encourage more involvement from industry in the selection and development of employability criteria (Mason, Williams & Cranmer, 2009). Universities of Australia along with the Business Council of Australia, the Australian Chamber of Commerce and Industry, the Australian Collaborative Education Network and the Australian Industry Group recently signed a Statement of Intent; one of the four main objectives of the statement was to improve the work readiness of university graduates. It becomes evident that the concept of preparing students to be work ready graduates has been identified as an area in need of improvement. The involvement of industry practitioners and employers in academia and university curriculum design is not a new concept. However, while the benefits of combining the forces of industry and academia to cater to the work readiness requirements of students is recognised, there still remains a lack of industry involvement in the development of university curricula.

Incorporating work readiness into educational pedagogy

Graduate employability has long been an important consideration for educators, employers and students. Some of the common methods of preparation for work readiness entail collaboration between universities

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and industry. These include: industry placements, shadowing, internships, and a year-out-in-industry component in degree programs. However, it must be noted that while student work readiness is highly valued by universities and appraised by employers, few models for preparing work ready students can be found in the existing literature. In recent research, Cavanagh, Burstone and Southcombe (2015), found that to prepare work ready students, university curricula should be designed by universities through corroboration both with industry employers and the students themselves. Moreover, research indicates that work readiness is to be incorporated into current day educational pedagogy (Banadaranaike & Willison, 2015). Smith et al. (2014) highlighted research which makes a contribution to the pedagogy of teaching, as a high priority to higher education teaching in Australia. Banadaranaike and Willison (2015) asserted that work readiness and employability skills are a product of one's cognitive and emotional skills; their research concluded that "educational pedagogy therefore needs to incorporate new ideas in the curriculum to benefit students and build a better rapport with industry and the community to create a more sustainable workforce for the future" (p.11). It is evident that educational pedagogy should incorporate the concept of work readiness to reflect the needs to equip the workforce of the future, yet there is little to no recommendations as to how this can be realised.

The Life Buoy Model

The Life Buoy Model proposed by Borg and Turner (2016) differs from other models that map employability skills in that it was a student-led model, designed to aid universities and students to identify the components needed to feel work ready, and ultimately, to enable students to combat the fear of being thrown in the deep end. Furthermore, the model extends to industry corroboration, in that it presents university based initiatives to foster work readiness in students which can only be realised with successful collaboration with industry professionals and the industry at large. Borg and Turner's (2016) model incorporates eight mutually exclusive components. These are broken down into i) four work ready characteristics required by students and ii) four university based initiatives which underpin the development of work ready characteristics. Furthermore, the model can be used to suggest means through which universities can work with industry to cater for the development of work readiness in their students.

RESEARCH AIM

This research uses the newly conceptualised work readiness model, known as The Life Buoy Model, to explore the ways in which one Australian university fosters the development of work ready characteristics in built environment students.

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METHODOLOGY

The research adopted a case study approach and focused on the School of Property, Construction and Project Management (PCPM) at a large Australian metropolitan university. The sample was constrained to the initiatives available for students completing any one of three undergraduate programs in the selected School. Documents relating to the work readiness of students in any one of the three programs in the School were collected, consistent with the understanding that the identity of a university can be defined through its documents (Owen, 2014); it was held that documents from the selected university would provide insight into the work readiness initiatives of the university. The data took the form of: student course guides, student program handbooks, course learning outcomes, career newsletters and online sources via the university website. Documents were analysed using the directed content analysis technique. When implementing this approach, "the analysis starts with a theory or relevant research findings as guidelines for initial codes" (Hsieh & Shannon, 2005:1277). The eight components of the Life Buoy Model served as the eight codes against which the initiatives were categorised. These are: self-confidence, sufficient preparation, smooth transition, solid foundation, sufficient work integrated learning, staff with industry experience and support systems. Once coded, the documents were further analysed to explore how the initiatives referenced in the documents contributed to the attainment of the Life Buoy work readiness component against which it was coded.

RESULTS

The results categorised all university initiatives available to students within the School of PCPM into the eight components of the Life Buoy Model. Table 1 depicts each of the components of the Life Buoy Model and ranks them in order of frequency by which they featured in the documents analysed.

Table 1. Ranking of Life Buoy Model Components by documented frequency.

Rank	Life Buoy Model Component	Frequency (By no. of times of appearance)
1	Solid WIL & Solid Foundation	7
2	Support Systems & Smooth Transition	6
3	Strong Links to Industry & Sufficient Preparation	5
4	Self Confidence	3
5	Staff with Industry Experience	2

The way in which the School of PCPM fosters the development of work ready characteristics in students in accordance with the components of the Life Buoy Model is as depicted in Table 2:

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Table 2. Work readiness initiatives in place at the School of PCPM.

Life Buoy Model Component	Initiatives in place at the School of PCPM at the selected University:
Self-Confidence	- Peer assisted learning programs to facilitate the dissemination of knowledge among students and develop students' academic confidence *(e.g. The Peer Assisted Learning Program is led by student mentors and is based upon the dissemination of knowledge among students).* - Specific services to aid students to develop employability skills to increase self-confidence when sourcing employment *(i.e. The Careers Toolkit is available to all students at the university; it is an online platform providing information to students regarding how to plan their career, apply for a job and make themselves employable.*
Sufficient Preparation	- Keeping the students informed about current trends in industry through newsletters, blogs, correspondence *(i.e. The School of PCPM has an official Facebook page and PCPM School News Blog).* - Industry mentoring programs to facilitate engagement between industry employers and students *(i.e. Employer of Choice Program and Industry Mentoring Program. Both programs encourage engagement between students and professionals within the specific field which the student aspires to enter into).* - Hosting of career days and similar events to bring prospective employers to engage directly with the students *(e.g. The School hosts 2 Career Days per year).*
Smooth Transition	- Provision of networking opportunities for students to interact with industry professionals *(i.e. The networking opportunities offered through the Employer of Choice Program enables the students to engage with potential future employers).* - Career platforms through which students are able to search for employment opportunities *(i.e. Careers Toolkit and Careers Hub are online platforms available to all students at the university).* - Career help/resources to provide information for career planning *(e.g. Students have access to careers counsellors).*
Solid Foundation	- Delivery of core courses within programs to cover the knowledge required for successful performance in the envisaged profession *(i.e. The PCPM programs mandate the completion of 32 courses; 3 electives and 29 core units).* - Having accredited programs *(i.e. The PCPM programs are recognised by the world-wide institution - the Royal Institute of Chartered Surveyors).*
Solid Work Integrated Learning (WIL)	- Offer Work Integrated Learning courses within the programs. *(i.e. The PCPM programs offer at least 1 WIL course which encompasses guest lectures, industry mentors and industry panels).*
Staff with Industry Experience	- Having teaching staff with real industry experience *(i.e. The university attributes its industry-aligned programs to having many of its teaching staff work with industry, community and businesses).*
Strong Links to Industry	- Annual industry nights to serve as networking events for students, staff and industry professionals *(i.e. The School hosts an Annual Industry Night to recognise the achievements of its students; awards are sponsored by industry professionals).* - Awards and scholarships sponsored by industry professionals to recognise the achievements of students within the university.
Support Systems	- Industry mentoring programs through which students can be connected to professionals in the field which they aspire to gain employment in *(i.e. The PCPM Mentoring Program pairs students in their penultimate or final year with mentors in industry).* - Provision of additional support systems *(i.e. Students have access to the university Counselling Service).*

DISCUSSION

The results indicated that all university initiatives available to students within the School of PCPM could be categorised into the eight components of the Life Buoy Model. In effect, the results reaffirmed the viability of the Life Buoy Model as a framework against which universities may wish to plan and design their work readiness initiatives. This suggests that the Life Buoy Model may serve as one of the new and applicable methodologies that Hager and Holland (2006) recommended universities look towards implementing to provide their graduates with the work readiness competence.

Self-confidence: The results demonstrate that universities can develop Self-Confidence by implementing a number of practices. These may entail offering peer assisted learning thereby increasing confidence in academic learning. In addition, universities may be able to offer courses through which students can gain employability skills sought after in industry. It is envisaged that by universities making such services available to students, educational institutions may be able to increase students' confidence in their ability to contribute to the workplace, a trait that was identified in Knight and Yorke's (2003) research.

Sufficient preparation: The results demonstrate that universities can foster Sufficient Preparation by informing students of the recent news related to industry. Furthermore, universities can ensure that the students are well connected to industry through mentoring programs, which encourage engagement between students and professionals within the specific field which the student aspires to enter into. In addition, universities may look towards bringing prospective employers to the School to engage directly with the students and share with them their knowledge of the opportunities and challenges within their industry, thereby preparing the students for what awaits them in industry.

Smooth transition: The results demonstrate that universities can facilitate a Smooth Transition by offering networking opportunities that enable the students to engage with their potential future employers. Universities may look towards providing career services, which help students to plan their careers. Universities may be able to offer an avenue for students to search for employment and internship opportunities which can aid students to explore career planning issues. It is envisioned that by aiding students in their transition to industry, universities may be able to alleviate the number of students who may experience reality shock, as identified by Kramer (1974).

Solid foundation: The results demonstrate that universities can provide a Solid Foundation by having clear learning/teaching areas, industry connections and career outlooks for students. Hager and Holland (2006) highlighted the misassumption often made by tertiary students that

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academic skill sets are identical to skill sets required in the workforce/industry. To expose students to the skills valued by industry, universities can have programs that are accredited by industry institutions, such as the Royal Institution of Chartered Surveyors' accreditation that is recognised world-wide.

Solid work integrated learning: The results demonstrate that universities can provide Sufficient Work Integrated Learning by offering core courses which address WIL components. Universities may look towards offering core courses which encompass the WIL components of guest lecturers and industry mentors. The importance of universities' capacity to offer WIL opportunities for their students is clear; studies have found that students who engage in Work Integrated Learning are better placed to find employment within their chosen field (Orrell 2004).

Staff with industry experience: The results demonstrate that universities can provide Staff with Industry Experience by employing staff with suitable academic qualifications coupled with relevant work experience in industry, community organisations or business. It is recognised that having teaching staff with industry experience "leads to a better industry and university relation" (Idrus, Dahan & Abdullah 2013, pp.1).

Strong links to industry: The results demonstrate that universities can develop Strong Links to Industry by organising events which give students the opportunity to connect with professionals within their prospective industries. Mason, Williams and Cranmer (2009) recommended that universities should encourage more involvement from industry in the development of employability criteria. Universities can endeavour to provide a platform which can be used by employers to communicate their requirements of employability criteria to students.

Support systems: The results demonstrate that universities can provide Support Systems by offering careers counselling services as well as general counselling whereby students may seek counselling support for issues such as: stress and lack of motivation to study. The transition from university to industry can prove extremely stressful for students (Davis 2010). Furthermore, research has found that employees in the built environment industry tend to experience high levels of stress (Love et al., 2010). Hence, it is essential that students are able to rely on relevant support systems being available to them at their universities.

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CONCLUSION

This study analysed the initiatives used by one Australian university to foster the development of the work ready skills of emerging Built Environment professionals. Through exploring the application of the conceptual Life Buoy Model, this research extends theory by providing an understanding of the real-life application of the eight components of the model to foster work readiness. While the findings of the study cannot be generalised due to the single case study, the results can serve as a basis from which other universities may wish to design and plan their work readiness initiatives. As work readiness within the built environment remains an area where little research has been undertaken, the next stage of the research seeks to further explore the concept from different stakeholder perspectives. Given the global concern about new graduates being inadequately equipped to thrive in the workforce, it is envisaged that this research will have benefits for students, universities and employers world-wide and that the benefits of this research transcend past the built environment industry.

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BIM EDUCATION -CASE NEW ZEALAND

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ABSTRACT

This article is a first step in a longitudinal research in New Zealand context to identify what impact national education approaches have on uptake of BIM education in individual tertiary institutes. Although BIM and BIM education as research topics are on rise, there is limited research on national approaches and their impact on width and depth of BIM education and through that graduate capabilities and BIM adoption by the industry. Case study approach has been selected to investigate first the challenges encountered by the tertiary institutes, how these can be addressed at national level and in later stages what the impact has been to the width and depth of BIM education and graduate outcomes. Only a limited number of countries such as United Kingdom have introduced national approaches to BIM education. In New Zealand National BIM Education Working Group (NBEWG) was established in December 2014. The group has representatives from eight tertiary institutes who have strong interest in including BIM as part of their programmes. NBEWG promotes integration of BIM into all architectural, engineering and construction programmes in New Zealand by providing national curriculum guidelines and guidance in adopting BIM curriculum. A survey was conducted among the institutes to identify the key challenges encountered in BIM integration. Among these were knowledge and skill gaps among faculty, crowded curricula, and limited time for development work.

Keywords: BIM education, BIM integration, curriculum, graduate capabilities, national approach

INTRODUCTION

In the recent years there has been a significant increase in research when it comes to BIM and BIM education (Abdirad and Dossick, 2016; Yalcinkaya and Singh, 2015). Lack of education and training are well known obstacles for BIM adoption and implementation (Yalcinkaya and

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Singh, 2015) and although programme and course level approaches to BIM education have been explored widely in the academic literature, there is very limited research on national approaches and their impact on BIM education in individual higher education institutes and on graduate outcomes. Only a handful of countries have adopted national approaches to BIM education Australia, Canada, New Zealand (NZ) and United Kingdom (UK) among these. The approaches to BIM education is discussed briefly to compare the approaches in each country with the approach taken by NZ. In NZ National BIM Education Working Group (NBEWG) was established in 2014 to create wider BIM awareness and encourage BIM adoption and implementation within the higher education institutes across NZ.

METHODOLOGY

This research explores application of national policies for BIM education, principally in tertiary/professional institutions, among leading countries in the field. The research principally concerns approaches to BIM education, especially in higher education. National policies for BIM education in these countries are critically reviewed and compared in order to draw conclusions towards development of standardized national policies fit for specific contextual requirements. Approaches towards promotion of BIM education, most especially at higher education level, in New Zealand are explored in depth. These policies are scrutinized in order to conclude the expected significant potentials of applying them at national level.

BIM EDUCATION

BIM education has been widely explored in the literature. Various authors such as Forsythe et al. (2013), MacDonald and Mills (2013), and Wong et al. (2011) have discussed BIM curricula models from programme levels to course levels. Sacks and Pikas (2013), Succar et al. (2013), Becerik-Gerber et al. (2011), Wang and Leite (2014) and Miller et al. (2013) have introduced competency targets and learning outcome frameworks for BIM in order to bridge the gap between education and the workplace by understanding the required concepts and skills. Woo (2007), Kamardeen (2013), Peterson et al. (2011) and Becerik-Gerber et al. (2011) have examined pedagogical challenges of BIM such as relevant disciplines and subjects, resource availability, teaching methods, available software/tools, and other supports to embrace BIM in the curriculum. Finally, practical challenges that hinder BIM education has been discussed by Gier (2015), Lee et al. (2012), Puolitaival and Forsythe (2016) and Underwood et al. (2015) to name a few: annual software package update, limited educational resources and expertise among staff, industrial requirements for graduates, lack of collaboration between academia and industry, limited up-skilling needs and so on. These previous studies

support the current some consensus in the BIM education which skills associated BIM are highly required in future graduates in the built environment disciplines (McLernon et al. 2015) and BIM education at both undergraduate and graduate levels should be provided to meet these requirements in order to respond to the inevitable update of BIM in the Architecture, Engineering and Construction (AEC) industry.

Although a large amount of research has been done regarding various areas of BIM education, there is very limited research on systematic and holistic approach to BIM education according to national strategies and consensus between educational institution and industry. Most of the literature is case studies either within one higher education institute, one programme or one course. The number of countries which have adopted national approaches is also limited.

NATIONAL APPROACHES ON BIM EDUCATION

Australia

In Australia there has been several regional or national BIM education initiatives.

Multi-disciplinary BIM education was identified as one of the six areas requiring priority attention in buildingSMART Australasia's (bSA) 'National BIM initiative' report in 2012. It called for a Nation BIM initiative to drive change. The implementation plan required a work program to "deliver a broad industry awareness and retraining program through a nations BIM education taskforce" based on a core curriculum and encourages pilot projects with a due date of 2013 (buildingSMART Australasia, 2012).

In 2012, Australian Institute of Architects published 'BIM Education, BIM in Practice' report. Three sections outlined the users, the learning providers and a draft collaborative education framework.

University of South Australia, University of Newcastle and University of Technology, Sydney recently contributed towards a collaborative design approaches to teaching BIM (Mills et al., 2013). There has also been a lot of work done in individual universities such as the 'Programme-wide implementation strategy' in University of Technology, Sydney (Foresythe and al., 2013) and 'Global passport through co-integration of construction immersive environments' with its 'Threshold capability framework' at RMIT University (London, 2015).

Australian Construction Industry Forum and Australasian Procurement and Construction Council released in March 2017 the BIM knowledge and Skills Framework. This is a significant piece designed to provide the principles, practices and outcomes as the foundation for building a curriculum, such as creating a shared language and a base for assessing learning progress. The document defines seven knowledge areas and maps processes and concepts across them with and six proficiency levels

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(Australian Construction Industry Forum and Australasian Procurement and Construction Council, 2017). In connection with the framework bSA is currently developing BIMcreds. An online testing tool aimed at certifying practitioner's skills in BIM and its application. BIMcreds are expected to be available in June 2017 (buildingSMART Australasia, 2017).

Canada

BuildingSMART Canada (bSC) released a 'roadmap' in 2014 to lead the transformation in achieving lifecycle BIM modelling in Canada. The roadmap proposed a collaborative approach based on six principles including one for education. The 'Educate' stream outlined in the roadmap starts with building a community of practice then suggests a two-pronged approach, developing a reference curriculum for BIM education and accreditation for institutes and simultaneously developing BIM training packages for stakeholders then providing certification for individuals. (buildingSmart Canada, 2014) In alignment with the roadmaps request for communities of practice, bSC established an education committee and an MOU was signed with Canada BIM Council (CanBIM) research & education committee (Poirier A. E., 2016). CanBIM began offering certification in 2014. It was designed to be an 'industry-wide benchmarking platform' and now provides four levels of Certification for Individuals as well as Educational Course and Program Certification (Canada BIM Council, 2016).

Although it seemed Canada was making good progress along the road map, in 2016 they were not any closer to having a national curriculum. A workshop was held to identify challenges around BIM education and to look for solutions. Six key actions were identified including establishment of core learning outcomes, online platforms to link stakeholders with academics, research, collaboration, seeking grant funds, and shifting the focus of BIM education more toward theoretical foundations (Poirier, et al. 2016).

United Kingdom

The United Kingdom is one of a few countries to take a national approach on BIM education with BIM learning outcomes framework which BIM Academic Forum UK has developed to acquire BIM knowledge and skills based on a long-term vision (BAF, 2013). This framework defines learning outcomes at undergraduate (level 4, 5, and 6) and postgraduate programmes (level 7) according to knowledge and understanding, practical skills and transferable skills. It also proposes BIM teaching impact matrix as an aid to determining the optimum requirements in the curricula with BIM level: Absent, Aware, Infused and Embedded. This BIM initiative has been not only shared amongst 55 members from 30 teaching centres across the UK, but also became the fundamentals for professional institutions – Royal Institute of British Architects (RIBA), Royal Institution of Chartered Surveyors (RICS), Institution of Civil

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Engineers (ICE), UK Contractors Group, Construction Product Association – to provide the skills and knowledge required for BIM adoption and implementation in the industry. For example, based on this framework laser-scanning to BIM process was adopted to enhance the teaching of BIM in undergraduate architectural education at University of Wolverhampton, UK (Heesom and Boden, 2016) and RICS (2015) published the global guidance which should be used as a source of reference for quantity surveyor (or cost managers) when BIM has been implemented in a construction project.

Others

Although the Nordic countries, especially Finland, have been in the forefront of BIM adoption, there has been very little happening until 2015/2016 at the national level when it comes to BIM education. BuildingSMART has been the common factor in most of the Nordic countries in coordinating BIM related education both when it comes to tertiary education and professional development. As an example, buildingSMART Norway has a programme to support teachers, which includes teaching curriculum for basic, client and consultant/contractor level. Their web portal also includes a large repository of student work related to openBIM and they organise student seminars on various topics in openBIM (buildingSMART Norway, 2016). BuildingSMART Finland has an education working group, which is looking at improving collaboration between those ones who need and who offer training. Their aim is also to develop curriculum and related material. (buildingSMART Finland, 2016)

Online search found signs of national BIM education initiatives in multiple countries, Hong Kong, Netherlands, Czech and US among other. However closer literature investigation didn't reveal anything further on these initiatives.

CASE NZ

National BIM Education Working Group (NBEWG) was established in December 2014 from the initiative of the BIM Acceleration Committee (BAC). BAC is an alliance of industry and government charged with coordinating efforts to increase and accelerate the use of BIM in New Zealand. NBEWG is reporting back to BAC. The charter of the NBEWG is:

1. Promoting the integration of BIM into all architectural, engineering and construction (AEC) programmes in New Zealand
2. Promoting and following national BIM guidelines, such as NZ BIM Handbook
3. Monitoring and guiding the integration of BIM in the membership institutes
4. Providing national guidelines for BIM learning outcomes

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5. Providing guidance in adopting BIM learning outcomes
6. Collaborating for joint activities and research projects to benefit BIM adoption and implementation in New Zealand particularly through education and training.
7. Working closely with industry in educational and research activities.

NBEWG has representatives from eight NZ tertiary institutes, which have interest in integrating BIM as part of their AEC programme delivery. The group meets physically and virtually throughout the year to record what is happening across the institutes in regard to BIM and to discuss and plan its response. Most institutes do not allocate specific time resources to this group, the members fit it into their current workload.

Since its establishment NBEWG has followed the work of BIM Academic Forum UK (BAF) closely. As an example, the national guidelines for BIM learning outcomes are based on learning outcomes defined by BAF.

Creating momentum in this space has been challenging. NBEWG conducted a survey around some of the issues the institutes were facing with the intent of using that data in providing direction for the group. Although that data set was small it was helpful.

NBEWG identified the following as challenges with high impact

1. Lack of BIM process knowledge among staff - BIM is not widely adopted in NZ: Adoption levels vary among projects, sectors, and businesses. Skills are not well developed among existing teaching staff nor recent hires. This is an industry wide issue. Not just the teaching space.
2. Lack of BIM software skills among staff - Buoyant construction environment means recruiting is difficult: BIM experienced staff are in high demand. Opportunities to upskill current staff are slim in NZ. BAC intends to keep BIM training as software agnostic as possible. Institutes vary in the software they use.
3. Crowded curricula, no room for BIM specific courses - Degree programs have some flexibility, but Diploma programmes have very if any flexibility. Diplomas have recently been reviewed and updated with specific mention to include BIM.
4. Lack of time in workload for BIM related work - Most of the institues don’t provide allocated time for BIM related work (unless considered research)
5. Lack of support from Colleagues - Teaching staff are generally assigned to a paper or course. Due to workload pressures teaching staff are generally unwilling to be involved on projects that do not impact or contribute to their paper.
6. No process training available for staff - As mentioned above NZ does not have many training opportunities available.

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7. Lack of support from management for BIM introduction - Just as the industry is still undecided on the benefits of BIM adoption it appears, so is the management within institutes.

NBEWG has a plan in place to advise and support the individual institutes. Among the tools are collegial support across the institutes; collaboration in resource development, resource sharing and research; and monitoring of training opportunities. BAC has also offered their support in increasing the understanding of importance of BIM integration. The plan is discussed more in detail in future publications.

CONCLUSIONS

The impact of proficient education on effective uptake of BIM for construction industry is eminent. Though, as highlighted earlier, BIM education has been promoted at domestic/regional levels, the context of applying nationwide BIM education policies has been limited. In fact, a nationwide perspective towards promotion of BIM education for AEC provides an overview, catering as a parent platform, for supplementary entities/institutions to adapt and extend the policies. Execution of an effective national BIM education policy for AEC stakeholders is expected to boost the uptake and pragmatism of using BIM at practical levels through standardizing clear policies. This is especially beneficial as the current BIM maturity level, even in many of the leading countries in the field including New Zealand, is still far from iBIM (BIM 3.0).

As a result, it is in fact of outmost importance to integrate development of national BIM policies with a clear view to current approaches taken by the design/construction industry. Though major standard policies can be adopted for various contexts, it is essential to localize and fine-tune such policies in accordance with national preferences in order to expect maximized efficiency.

In this line, the role of tertiary/professional institutions in adapting effective standardized national policies to educate BIM-ready graduates is crucial. In fact, forming the education landscape with a national perspective on graduating BIM-ready professionals, is anticipated as a significant step towards nation-wide effective uptake of BIM for the design/construction industry at established levels.

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FORM AND PERFORMANCE: TALL CONCRETE STRUCTURES AND APARTMENT QUALITY IN MELBOURNE'S RESIDENTIAL TOWERS

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ABSTRACT

Does the structural configuration of tall buildings affect the quality of apartment design? The architecture of tall buildings relies strongly on quantitative inputs. Yields of development, overturning moments, dynamic responses and lift-waiting periods, for instance, are all items that can be readily measured, and the built form of tall buildings has to work within these strict and seemingly unchallengeable constraints. However, these same parameters also impact on the spatial quality of the apartments produced. Four case studies, taken from recent additions to the stock of high rise apartment towers in Melbourne, are used to highlight missed opportunities that follow from an incomplete application of performance-based design, where façade concepts, structural, and construction inputs prevail over those of an overarching spatial integration. The mandate of performance-based design, if driven chiefly by mono-disciplinary concerns, remains necessarily incomplete unless it is verified and corroborated by qualitative methods able to discern broader quality criteria for end-users. A sample of apartments currently under construction in Melbourne's CBD indicates that the emphasis on marketing, structural, and construction demands remains the key driver of current built outcomes, relegating spatial quality and functionality of the dwellings produced to a lower rank of priority. Recently introduced built form controls with public benefit provisions make Melbourne an ideal environment to test, evaluate and discuss within the industry a new range of typologies for residential towers. But such guidelines should start by acknowledging a broader and more evidence-based concept of innovation, design quality and performance in design.

Keywords: Performance-based design, tall buildings, built form, apartment space quality, structural typology.

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INTRODUCTION

While tall buildings in Central Business Districts are generally associated with global corporate business and prestige office buildings, residential towers are becoming the dominant tall building typology of many cities worldwide. The central city of Melbourne, for example, has become, after the Global Financial Crisis, the epicentre of a boom of high rise and residential construction activity. In 1995, the twenty tallest buildings of the city ranged in height from 130 metres to 265 metres. These, with the exception of one mixed-use office and hotel building, were all commercial offices. By 2020, considering the projections of the Council on Tall Buildings and Urban Habitat (CTBUH, 2017), the tallest 20 buildings of the city will range in height from 240 metres to 325 metres, and among these, only three buildings – completed between late 1980s and early 1990s – will be office buildings. The rest of the tallest buildings in the skyline will be mono-functional residential – at times with a small component of commercial floor space at lower levels - or mixed-use residential and hotel towers. By the end of this decade, Melbourne could become one of the cities with the highest number of buildings taller than 200 meters on the planet, outnumbering in prospect – with a building stock comprised in prevalence by residential condominiums - global cities like Chicago, Kuala Lumpur, Tokyo and Singapore (Marfella, 2016).

In the context of this radical urban transformation, and following growing concerns related to excessive density and poor built form outcomes, the State Government of Victoria introduced in 2016 the Central City Built Form Review, which includes a set of initiatives to improve the built form outcomes of inner city high-rise developments (DELWP and Hodyl, 2016). The great majority of central city apartments in Melbourne are purchased by non-owner-occupiers as an investment and the separation between owner and resident, combined with the primacy of economic yield and asset price growth in purchasing decisions, have raised questions about the spatial quality and functional liveability of the apartment stock. In 2017, the Victorian Government amended the Victorian Planning Provisions to include a newly formulated Better Apartment Design Standards, for apartment towers higher than four storeys (DELWP and OVGA, 2016).

The introduction of these two major changes to the regulatory environment will have a significant effect on high-rise residential buildings in the city, and shift the balance from a highly deregulated and discretionary performance-based approach of the recent past into a more prescriptive framework of control. Notably, the changes introduced by the State Government of Victoria are in counter-tendency with the latest release of the National Construction Code of Australia, which is almost entirely structured around the concept of performance-based design. Such changes are subject of intense public debate, which has even reached an international forum (Parsons and Addison, 2017).

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Some of the central issues raised by this local debate pertain to the broader question of what determines quality and innovation in design vis-à-vis the degree of prescription (or lack thereof) in urban regulatory frameworks. Stemming from the recent events of the City of Melbourne, and using the built-form outcomes of a selection of local projects, this paper highlights and examines the existence of a predominant structural solution, which has been deployed in Melbourne's residential towers, where a lack of integration with the architectural design intent plays a key role for the limitation on the size, quality and ergonomic outcomes of the living spaces inside the buildings.

METHODOLOGY

In central Melbourne, all building proposals that are larger than 25,000 square metres in gross floor area fall under the direct control of the Planning Minister of the State of Victoria, who receives comments and recommendations from the City of Melbourne planning officers and City Council via meetings and deliberations held by committees such as the Future Melbourne Committee (FMC). Using public information retrieved from meeting minutes of the FMC and drawings submitted for planning approval, a sample of four tall buildings projects approved in central Melbourne over the last five years were selected. Three out of the four projects were submitted for approval before the recent introduction of new built-form controls, and one after.

There are many factors, both qualitative and quantitative, that can contribute to the spatial quality of apartments, which here cannot be covered in depth for reasons of space. The focus of this paper is on the specific issue of minimum room dimensions and apartment layouts vis-à-vis the configuration of structural elements, such as columns and shear walls. Other limitations of this study relate to the small pilot sample of four buildings, and by a qualitative assessment of the structural layout of the buildings, which for this study could not be corroborated by a quantitative-based or comparative assessment of the engineering performance of the typology that has been identified with other structural typologies.

The typical floor plans of the four towers were analysed in order to identify the structural design typology employed with the aim to identify patterns and relationships between the structural grid and the residential spaces. Selected individual apartments were also analysed to highlight quantitative and qualitative features of the internal layouts of the units, seeking to identify the influence that structural members such as shear walls and columns, may have on spatial layouts. The four project samples were chosen in different areas of the inner city, where new residential building clusters under development respond to different types of market demand. The sample includes two up-market 'luxury' projects, one

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designed by a famous international architect and located at the western end of city (Case Study A), and another designed by a local architect and located in Southbank (Case Study B); the other two projects are lower-end speculative projects located in the north-western area of the CBD and were designed by another local architect (Case Study C and D).

CASE STUDY ANALYSIS

The characteristics of the structural grid employed on the residential floor plates of the four buildings in consideration are shown in Table 1. Three of the four case studies (A, C and D) are approximately rectangular with a North-South and East-West orientation, which reflects the orientation of the city grid where they are located. The maximum span, centre-to-centre, between shear walls ranges from 8.4 metres to 6.75 metres on the longer axis, and from 6.8 metres to 4.5 metres on the short axis. Case Study A has a typical floor shape nearly square, although articulated by projections, which result in different structural grids along the North-South and East-West axes. Case Study A uses large shear rectangular columns in conjunction with structural circular columns, a solution not dissimilar to the shear walls-only approach used in the other three buildings. The Maximum distance between columns is in this case 8.5 metres along North-South axis and approximately 7 metres along the East West axis.

Table 1: Key Characteristics of Typical Residential Floor

Case Study	Grid Span c-c (mm)		Distance from Core to Facade		Approx. H/W Ratio	Façade Perimeter m	Core Area m2	No. Apts.
	NS	EW	NS	EW				
A	8400	5451	9820	9695	5	128	224	12
B	8510	7065	14020	14630	7	174	187	18
C	6750	4500	6600	10000	8	133	194	14
D	7000	6800	7910	12115	6	122	96	14

Case Studies A and B have a fairly constant façade to core depth of habitable space around a central service core, which varies from 9.7 to 9.8 metres and from 14 to 14.6 metres respectively. Case Studies C and D are more elongated in plan and have depth that varies from 6.6 to 10 metres and from 7.9 to 12.1 metres respectively. The slenderness ratio of the towers ranges from approximately 5 (Case Study A) to 8 (Case Study B) and the length of the façade perimeter for a typical residential floor

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ranges from 122 m (Case Study D) to 174 m (Case study B). Finally, the number of residential apartments per typical floor ranges from 12 (2 one-bedroom units and 10 two-bedroom units, in Case Study A) to 18 (8 one-bedroom units and 10 two-bedroom units in Case Study B). The typical size of one-bedroom apartments across the case studies was between 45 to 50 square metres, and the one of two-bedroom apartments was 65 to 70 square metres.

FINDINGS

By comparing the spatial characteristics of the structure of these four buildings with the minimum room sizes indicated by the Better Apartment Design Standards of the State of Victoria (see Table 2), two sets of observations follow.

Firstly, the four buildings clearly present a consistent structural typology, which is defined by a central core and an array of shear wall dispersed around the floor plate. These shear walls are usually located well inside the habitable floor plate and they are disengaged from the perimeter of the building, where the edge is free to be articulated with curves, protrusions or indentations at the discretion of the external architectural expression. This structural approach is in line with the structural typology and the construction methods used on a number of all-concrete and glass-clad residential towers that were recently completed in Melbourne. The concrete core (built with self-climbing jump forms) and the concrete shear walls (built in situ or precast) are completed by post-tensioned concrete flat slab construction. This structural typology satisfies profit-driven development mandates, where floor to floor height can be minimized and high-rise construction can progress with minimum risks by eliminating from the critical path the erection of vertical elements along the perimeter of the building.

Secondly, there is a conflict in the relationship between the typical distances between shear walls observed in the residential floor plates of these case studies and the minimum dimensional criteria for rooms set by the Better Apartment Design Standards. The more spacious arrangements observed in the case studies, suggest that shear walls supporting flat slabs can rarely span beyond 8.4 to 8.5 metres. Two bedroom apartments are therefore not possible to be accommodated within such spans, unless the second bedroom is setback as a deep and narrow L-shaped 'saddleback' with a very restricted exposure along the façade. In all of the four case studies observed, two bedroom apartments are forced to work around the structural grid, with second bedrooms and bathrooms having to swallow thick, deep shear walls in their interiors. This limited integration with structural elements is often at odds with spatial quality along the corners of the buildings whereby apartments are not placed within discrete spaces between structural elements and are forced into a

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patchwork of spaces that does not bear a direct relationship to patterns of use and distribution. By contrast, the layout of internal structural elements in the basements that house car-parking respond with clinical success to the dimensions of the space required for the circulation of cars.

Table 2: Minimum Room dimensions from the Better Apartment Design Standards

	Studio or One Bedroom Apartment		Two or more Bedroom Apartment	
	Minimum Width	Minimum Depth	Minimum Width	Minimum Depth
Main Bedroom	3000	3400	3000	3400
Other Bedrooms	-	-	3000	3000
Living area	3300	10 m2 minimum area	3600	12 m2 minimum area
	Ratio of Ceiling Height to Room Depth		Open Plan Layout (Kitchen-Living) Maximum depth	
Habitable room	2.5:1		9 m (ceiling height 2.7 m min)	

Consequently, the Victorian design guidelines summarized in Table 2 set the stage for an ongoing proliferation of one-bedroom apartments, where a bedroom and living area can easily be placed adjacent to one another (satisfying minimum light/ventilation/views) with rooms sized at the minimum dimensions, already observed in two of the four buildings analysed. In summary, the new controls seem well-fitted for the already established structural template of central core and internal shear walls only if minimum dimensions of rooms are stipulated.

DISCUSSION

The definition of a tall building varies from place to place in terms of absolute height, but an accepted definition of this typology considers both physical aspects relative to a surrounding context such as height, proportions, slenderness, and the use of construction technologies that are specific and necessary for the typology in question. These last criteria reflect the fact that all tall buildings are a particular building typology governed strongly by a few key physical criteria, such as vertical circulation, and other performance criteria that are mostly structural, such as wind resistance and stiffness (CTBUH, 2011).

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While some of the physical and technological constraints on tall buildings may be universal for all designations of use, the drivers of architectural and spatial quality are diverse and vary significantly between commercial office and residential use. Commercial office spaces require maximum flexibility within the lettable area and favour open plan, column-free design on each floor. Such expectations of spatial quality are essential for rentability and determine that structural elements work within such restraints. So, for example, in the case of a centre-core floor plate, the primary structural elements, apart from the core itself, are ideally located along the edge of the floor, typically in the form of a perimeter frame with stiff columns and edge beams, thus leaving any space between the frame and the core unobstructed by structural elements. This configuration is also conducive to regular and rectilinear perimeters and façades that, combined with column free interiors, are generally more desirable and rentable than irregular or geometrically hybrid perimeter profiles of the floor. Notwithstanding some exceptions, typological patterns of this kind can be observed in the tall office buildings of many cities worldwide, and they are a dominant characteristic of Melbourne's commercial tall building stock (Marfella, 2010).

By contrast, residential high-rise buildings are less dependent on column-free space, where primary structural elements can be located in the form of shear walls along party walls between units. This in turn, allows for more freedom of the architectural treatment of the façade, leading to the production of 'iconic' architectural imagery and becoming a vehicle of effective marketing for the sale of the apartments (Gower, 2015). This opportunity of architectural expression stems from a number of factors, including the large percentage of apartment purchases by investors in central city housing markets, and the wide-spread practice of selling 'off-the-plan' in Australia, where developers are required to pre-sell a percentage of apartments in order to unlock the development finance required to construct the building (Martel, 2012). Structure, therefore, in the case of residential buildings is preferentially placed within the floor plate to allow for maximum flexibility with the façade, including curves, undulations, indentations and extrusions.

It is significant, however, that recent high-rise construction trends in Melbourne CBD have easily borrowed the overall physical appearances and technologies from the older generation of tall office buildings of the city, notably with the widespread adoption of unitised curtain walls of glass. But this knowledge transfer did not occur – for the detriment of apartment quality - with regard to the structural systems, which in the case of office buildings can rely to a well-established array of solutions able integrate architectural expression, user flexibility via open space, and structural efficiency with steel, concrete and composite elements (Ali, 2001; Ali and Moon, 2007; Kowalczyk et al., 1995).

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In view of these considerations, these case studies suggest the existence of a disconnection between architectural expression and structural engineering in contemporary tall residential buildings. These two central disciplines should be integrated to meet the specific physical and technological challenges of innovation that are implied by the very definition of a tall building and by the tradition of architectural engineering associated with this building typology. The evidence of recent high rise developments in Melbourne indicates a historical counter-tendency, where the two disciplines have been relegated to fit into a minimum common denominator that satisfies development return and large-volume production, above all else, rather than innovation in the production of spatial quality and high rise living to meet growing demand for apartment living.

CONCLUSION

The argument presented from these case studies is twofold: on the one hand, fears that lack of deregulation may stifle innovation seem unfounded for a building typology that, in a highly deregulated environment before the introduction of more prescriptive controls, has shown hardly any strategic elements of innovation and competitive variety despite a boom in construction of apartment buildings. On the other hand, the introduction of 'better' criteria of spatial design for apartments and a control by authorities on built form, in the case of tall buildings, does not seem likely to stimulate radical improvements on the local typology, unless authorities are prepared to upset the current template of development and key stakeholders are prepared to embrace a broader notion of performance in design that starts with the integration of architectural expression with advanced structural engineering. These considerations lead to the necessity for further evidence-based inquiries into the dynamics of interactions between the different parties involved in tall residential buildings in Australia today (e.g. developers, designers, engineers, and contractors), to establish to what extent these parties are committed to engage in a coordinated effort for the delivery of projects according to the highest and most integrated interpretation of performance-based design.

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IDENTIFYING BARRIERS TO RETAINING FEMALE PROFESSIONALS IN ENGINEERING AND CONSTRUCTION ORGANISATIONS

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ABSTRACT

The construction and engineering industry remains to be one of the most male dominated industries in the world, with between 10 and 25 percent of its employees being female. It is believed that only 62% of women who pursued engineering stayed within the industry. Research suggests that the biggest hurdle the industry needs to overcome is changing the culture within the industry. For engineering and construction organisations gender diversity adds to the opportunity to engage a more diverse range of skills and ideas, with gender diverse organisations being 15% more likely to outperform their respective industry median. It also enables organisations to match the projected more gender diverse client teams and reflect the stakeholders in the communities they serve. The aim of the study is to provide a better understanding of how do we attract and retain female professionals within the construction industry and ensure gender diversity within senior leadership teams. An exploratory qualitative study was conducted with 3 females and 1 male working within the construction and engineering industry. The results suggest that the majority of interviewees joined the construction industry due to the encouragement of a family member and all agreed that having a gender diverse team was important as it creates for more diverse communication with the clients and stakeholders. However the difficult workplace culture and stereo typing still exists particularly around the need to have to work long hours which creates difficulties when trying to balance family and career.

Keywords: Construction Industry, Employee Retention, Engineering Industry, Gender Diversity.

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INTRODUCTION

Hunt et al (2015), shows that gender-diverse companies are 15% more likely to outperform their respective industry medians. It is also seen that companies that can attract and retain this form of diversity, have a more competitive advantage. Shoellkopf (2014), outlines that "Fortune 500 companies with at least three female directors have seen their return on invested capital increase by at least 66%, return on sales increase by 42%, and return on equity increase by at least 53%".

The US Department of Labour (DOL) identifies an occupation as being a "non-traditional" occupation when women comprise of less than 25% of its workforce. As of 2008, (DOL, 2009) and outlined by Sewalk et al (2015), women accounted for 8.2% of construction managers and for 3.3% of the construction workforce, making it "non-traditional". Results are also similar for related industries such as architecture, for which women make up 24.8%, for engineering technicians which women make up 18.5%, for industrial engineers which are made up of 14.9% of women and for civil engineers which are made up of 10.4% of women. It is outlined that the gender distribution disparity in construction emerges at the initial stages, such as university entry level With an average of only 7.8% of female students choosing to go into construction management and women continue to be underrepresented in science, technology, engineering, and mathematics (STEM) fields (Bigelow et al, 2015). These demographics are pushing companies to look outside of recruiting only men and to consider how they would attract more women into the industry (Clarke and Gribling, 2008).

The ability to predict and develop policies and programmes and environments that enhance work-life balance and promote organisational commitment is important to minimising employee turnover (Malone et al, 2013) and to help attract and retain female engineers. However the belief is that the engineering industry is a competitive and conflictual environment, "where women are overtly and covertly discriminated against by men who use structural systems to undermine their participation" (Dainty et al, 1999, pg 239).

The construction industry does not attract significant numbers of women to its labour force. However, due to potential expected growth in the field, construction companies will need more women to meet their labour needs, (Sewalk et al, 2015).There is a need to understand how do we attract and retain more female professionals within the construction industry and ensure gender diversity within senior leadership teams.

LITERATURE REVIEW

A range of reasons have been suggested for the lack of women entering and staying in the construction industry. Sewalk et al (2015) suggests that many women feel like outcasts, unwelcome within the industry. Dainty et al (2000), conducted a study which showed that recruitment was routinely done by informal and personal sources, putting women at a

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disadvantage. As per Sewalk (2015, pg 242), "the man's way of doing business is deeply ingrained in the construction industry and many current male workers and owners of construction companies are very reluctant to change their existing hierarchies and work practices." Another point raised by Sewalk et al (2015), was that a great barrier was that of work-life balance for women within the industry and women were discouraged from working in construction if they wanted to have a family in the future, as maternity leave or other parental leave is not accepted within the industry. In addition, it was apparent that extended working hours (Dainty et al, 2000), failure to get equal opportunities and promotions (Hurley et al, 1999) lack of salary increases (Wilkinson, 1992) and sexual harassment (Fielden et al, 2000) were also barriers that were evident.

Findings from Fouad (2014) concluded that only 62% of women who pursued engineering, stayed within the industry, 11% of these women never entered the field and 27% ended up leaving the industry. Amongst the women who left, two-thirds said they pursued better opportunities in other industries, and the other third stayed home because they felt companies didn't accommodate work-life concerns. From the women who left to go to other industries, 54% of these women went on to become executives. That women are seven to eight times more likely to attract unwanted sexual attention and 42% of cases leads to unexplained resignations of the victims. A study by Dorsey and Minkarah (1992) found that 37% of female respondents in their study were thinking about leaving their jobs because of mistreatment. Watts, (2007) and Sewalk et al (2015) suggest that the culture of the industry with its light hearted sexist joking and more subtle masculine behaviour may undermine female colleagues.

Sewalk et al (2015), suggests that lack of training, lower pay and career progression are also barriers to retaining women within the industry. Women are more likely than men, to leave the industry within the first 10 years of their careers (Dainty, 2000). This is hugely due to slow career progression and a "disillusionment with the culture," (Sewalk, 2015, pg 241). Perreault (1992), suggests that men continue to assume that women are not capable of performing the work required within the industry. Nor are they able to manage male employees or balance work and life commitments.

Sewalk et al (2015), discusses the study undertaken by Moore (2006), who suggested that the biggest single barrier for career development was finding a balance between personal and professional lives. Menches and Abraham (2007), also confirms that family matters strongly influences women's career paths. In a survey by Fielden et al (2001), of men and women, it was concluded that all participants felt that flexible working hours and access to childcare would increase the opportunities for women

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in the construction industry. Dainty et al (2000) identified that women in their 20s and 30s found it difficult to gain entry into the industry as managers were conscious of the potential responsibility women would have to face regarding their families in the future. Women therefore felt penalised for wanting to have families as they were seen as unreliable if they required time off work. A common perception became that women felt they needed to choose between a career and having a family and that it wasn't possible to have both.

Institution of Professional Engineers New Zealand (IPENZ) have also conducted research into these issues investigating barriers to women remaining and progressing in the engineering industry. Their report Women in Engineering: Preliminary Report on WIE Survey (2008) and further discussed by Ayre (2011) determined that workplace culture strongly influenced female engineers. It showed that 21% of female engineers had reported being sexually harassed, 39% reported having experienced gender discrimination and 25% had reported having experienced bullying. An interview with Tracey Ayre (2014), concluded that stereotyping and workplace culture, particularly around the need to have to work long hours, the lack of visible role models and the lack of transparency in pay, were all key reasons for women leaving the industry.

The literature review reveals a number of themes for consideration. There are significant benefits to having a more gender balanced workplace; there are a range of barriers that exist to attracting females into the industry and retaining them in the industry. Research indicated that the biggest hurdle the industry needs to overcome, is changing the culture so that males accept their female counterparts as equals. As suggested by Dainty (2000), rather than just recruiting more women into the industry, the focus should be on changing the culture within the industry.

Research Method

The purpose of the study was to gain a better understanding of how do we attract and retain female professionals within the construction industry and ensure gender diversity within senior leadership teams. The nature of the research aim required an inductive approach to be taken as this is more open ended and exploratory in nature and would enable initial findings to emerge from the construction context. Qualitative research was selected as a methodology as it is ideal for establishing perspectives and answering the 'how' and 'why', this was appropriate given the complex nature of the construction industry and its lack of women being represented.

The data collection method of face to face semi structured interviews was chosen as it is well suited for the exploration of perceptions regarding complex and sensitive issues (Barriball and White 1994). The interviews

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incorporated both open-ended and more theoretically driven questions which helped to draw interviewees more effectively into the topic under study (Galletta and Cross, 2013). The semi structured interview schedule was developed based on the key themes from the literature including the benefits of gender diversity, lack of women entering the industry and their subsequent progression and retention.

In terms of sample size, qualitative research focuses on exclusivity of text and possibility of different interpretations from the data, the size of the sample is limited (Marsh and White, 2006). They further stated that the focus of research should be transferability rather than generalizability per se. For the purpose of this exploratory study, a homogeneous sampling method was adopted (Patton, 1990). This method involves selecting a small homogeneous group of construction industry professionals (unit of analysis) for examination.

As the research was exploratory in nature the sample selection process involved selecting 4 individuals at varying stages of their careers with the intention that their experience would provide rich data. High achieving individuals were chosen through network connections. To ensure that these people were taking all steps possible to progress their careers, with aspirations of leadership roles within their current or near future.

Table 1 outlines the interviewees' demographic profiles, indicating their gender, age, family status, breadth and depth of industry experience in the construction industry.

Table 1: Interviewees' Demographic Profiles

Interviewee	Gender	Age	Family Status	Job Role/ Organisation Type	Length of professional experience
1	Female	20-24	No Children	Professional engineer, in a junior to intermediate level role	Within the first 5 years of their career
2	Female	25-34	No Children	Professional, non-engineer, in an intermediate to senior level role	Within the first 10 years of their career
3	Male	25-34	Has Children	Professional engineer, in an intermediate to senior level role	Within the first 10 years of their career
4	Female	35-44	Has Children	Professional engineer, senior level role	10 years plus work experience

Content analysis was used to analyse the data as it allows for data interpretation and making inferences for identifying the key message conveyed (Stemler, 2001). It also allows the researcher to make for

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making valid inferences from the data to their context, helping to provide knowledge, and new insights (Krippendorff, 1980; Elo and Kynga, 2008). This approach meant that the data collected was rich and in depth. The themes that emerged from the data are now presented.

RESULTS AND DISCUSSION

Three main themes emerge from the data for discussion including reasons for entering the industry, the need for gender diversity in the construction industry and issues around entry, progression and retention of women.

Entering the industry

The interviewees were asked to explain their reasons for joining the construction industry as a career. The majority of interviewees joined the construction industry due to the encouragement of a family member. Three of the interviewees had a male role model of a father or uncle in the industry. Interviewee 1 stated *'Father was an engineer and I would not have gone into it if not for him'.* Interviewee 3 highlighted that one of the reasons for him choosing to go into the industry was due to his interest in the STEM subjects. This finding supports the work of Sewalk et al (2015) who stated that unless parents were involved within the industry, young girls were not attracted to it.

The need for gender diversity

All participants felt that there is a gender gap issue within the industry. Interviewee 1 explained *'Yes. There is a gap from the university level already. With this growing as it heads into senior leadership positions.'* Two of the interviewees went on to explain that this gender gap has implications for professional women in the industry including '*…feeling unwelcome within the industry. You question your own abilities. Feel less respected,* (Interviewee 2). To the need to work long, excessive hours, in order to prove themselves. In most cases feeling it is required to work harder than men in order to be perceived as being on par with them.

All participants agreed that having a gender diverse team was important, noting that it creates for more diverse communication with the clients and stakeholders. Interviewee 3 confirmed that *'Yes… Makes for a more interesting group of people to work with and outcomes are improved. Allows for a greater range of perspectives.'*

The interviewees felt that women bring a range of positive attributes to the workplace including empathy, sensitivity and a strong teamwork focus. However all of the female interviewees felt that the need to play down their feminine identity to try and fit in to the industry .Interviewee 1 explained '…*Pressure to have a lot of physical hobbies to try and fit in with male counterparts. If you talk about female things, your perceived IQ levels drop'.*

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Entry, progression and retention of women in the industry

The interviewees were asked to discuss their perceptions concerning the lack of entry of women into the construction industry as well as the causes for women to leave the industry. A key fact that was outlined by the interviewees, was that girls are not encouraged to enter into STEM subjects at a young age and is a strong factor as to why they do not choose engineering as an option at university level. '*Biggest barrier to entry would be at university entrance level. Perceptions of industry being too male dominated'* (Interviewee 3). This therefore creates that gender gap at an early stage.

The interviewees confirmed that it is still a male dominated industry and therefore women feel discouraged to enter. Interviewee 2 offered a range of reasons including *'Very male dominated. Hard to reach leadership positions. Hard to balance family and career.'* This confirms the work of Ayre (2014) who concluded that stereotyping and workplace culture don exist, particularly around the need to have to work long hours.

Perceived reasons for leaving the industry included better opportunities in other industries but most focused on the issues concerning the challenges of balancing work and life 'particularly if raising children' (Interviewee 3) and Interviewee 4 who stated 'Women tend to want to leave to have a family and find transitioning back difficult.' This supports the findings of Fouad (2014) who confirmed that two-thirds of women who left the industry pursued better opportunities in other industries, and the other third stayed home because they felt companies didn't accommodate work-life concerns.

In terms of the barriers that exist to personal career progression interviewee 2 and 4 focussed on the issue of the long working hours '*Women have to work harder/ longer hours to prove themselves - especially on site.'* Whereas Interviewee 3 stated that *'White males are progressed ahead of others because of their perceived leadership potential.'* Interviewee 1 outlined the lack of mentorship available in the industry as a barrier as well as the lack of acceptance by men stating that *'When women are friendly with male colleagues, they are seen as flirty. Males find it hard to accept them into their social circle.'* Twenty years later this supports the work of Watts (2007) who outlines, subtle masculine behaviour is used to undermine female colleagues.

Participants felt that maternity leave or working part time did prove to be a setback in terms of their progression opportunities. Interviewee 2 felt that think *'maternity leave would definitely affect career progression. You have to be "seen" to progress. Don't usually pick up where you left off.... Fall behind.'* Interviewee 4 had direct experience of maternity leave affecting their career progression stating that *'This has slowed down my career progression. It is hard to work part time hours as you tend to do a lot of over time. It is easier if your husband has more flexibility around*

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their job. Pay gap following maternity leave.' Interviewee 2 felt afraid to even bring up the prospect of having a family as she feels she would be discriminated against and automatically overlooked for senior roles due to the perception that she would choose family obligations over those of her professional commitments. This supports the work of Dainty et al (2000) who outlined that managers are conscious of the potential responsibility that women could face if choosing to have a family, thus penalising them before they've even made the decision.

Conclusions

The aim of the study was to provide a better understanding of how we attract and retain female professionals within the construction industry and ensure gender diversity within senior leadership teams. The results of this exploratory qualitative study suggests that women remain to be underrepresented within the industry. Although there continues to be some growth over the years, it is not enough to sustain labour demands or meet the changing demands of the clients and the greater environment and social requirements.

The study confirms that female professionals joined the construction industry due to the encouragement of a family member rather than the attractive nature of the industry to young people. There is a requirement to attract more female professionals into the industry and having a gender diverse team is important as it creates for more diverse communication with the clients and stakeholders. The difficult workplace culture and stereo typing still exists and undermines women in the workplace. There are issues concerning the need to have to work long hours which creates difficulties when trying to balance family and career. People felt that maternity leave or working part time was a setback in terms of their progression opportunities.

These results provide examples that the industry has not progressed as far as it would have liked in the last 20 years in terms of diversity, however due to the pilot nature of the study more research is needed in this area. Further research could help to unpack these issues in more detail and to allow these initial findings to be verified. Further research in this area is currently taking place as part of a three year project to examine the issues generated from this study as part of a current larger qualitative study examining women's career paths in the construction industry in New Zealand.

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A COMPARATIVE STUDY OF TRADITIONAL AND COMPRESSED SCHEDULING ON UNDERGRADUATE CONSTRUCTION STUDENTS' PERFORMANCE

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ABSTRACT

There is a continual need to modify the way tertiary institutions do business to meet the needs of a changing society. The focus has been on success and retention whereas the new strategy in New Zealand supports wider economic growth and prosperity. There is a need for tertiary organisations to think about existing models and means of delivery, inclusive of new and emerging technologies as well as a continued expectation of the ability for tertiary institutions to deliver content via time and cost efficient means. Traditional scheduling involves concurrent enrolment in numerous courses with less contact time over a 16- week timeframe, whereas compressed scheduling focusses on 2 courses per 8 weeks with more instructional time per week. This paper evaluates the use of compressed scheduling methods for first and second year courses on an undergraduate programme in construction in New Zealand. The quantitative study compares end of course exam results, gender, age enrolment and residency status of 2 first year courses and 3 second year courses for the students from 2011 to 2016. The outcomes are consistent with the literature and support the proposition that a similar student learning experience can be achieved in traditional and compressed courses. The findings of the study suggest that concerns associated with offering courses or providing alternative teaching pedagogies associated with traditional and compressed scheduling are unfounded. Interestingly the females in the study performed better in a compressed schedule as compared to a traditional schedule and warrants further research.

Keywords: Keywords: Adult Learning, Compressed Scheduling, Construction Student Performance, Traditional Scheduling.

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INTRODUCTION

Tertiary institutions are expected to modify the way they do business in order to meet the needs of a changing society. Historically the focus was on success and retention, however the new strategy highlights the needs of tertiary education to "better equip individuals with the skills and qualifications needed to participate effectively in the labour market (MoE, 2014, p. 2). There is a need for tertiary organisations to think about the existing models and means of delivery, inclusive of new and emerging technologies.

McCoy and Taylor (2000) agree that time problems have caused educators to look at alternatives to the traditional block schedule and that the use of time has been a focus for change in education and education reform. According to Papadakis (2000), making modifications to a schedule will bring about positive changes for the student. However Arnold (2002) feels that administrators have rushed into the adoption of alternative scheduling based on its claimed advantages, but without any real data to support its benefits. Hackmann (2004), suggests that alternative schedules are implemented for a variety of reasons, including stimulating curriculum changes; addressing staffing needs; improving instructional strategies etc. This research study aims to offer insight into how the introduction of compressed blocks of teaching effects student performance, thus providing better understanding and identifying possible areas of improvement. The specific objectives of this study were to:

- Establish if the new compressed block scheduling delivery format has influenced student performance.
- Establish if, any one group (gender, age, enrolment and residency status) benefits more than another as a result of alternative scheduling methods.

LITERATURE REVIEW

Widespread reforms, in response to the New Zealand Tertiary Teaching Strategy 2014-2019 has impacted almost every aspect of teaching and learning from examining new teaching methods; emerging technologies and blended learning etc., except how classes are scheduled. Scheduling is the systematic arrangement that brings students, teachers, curriculum, and resources together (Traverso, 1996). More recently it has been described as how often, and for how long a course takes (Dunn and Hooks, 2015).

Clark and Linn (2003) indicate that how much time is allocated, as well as how institutions organise that time in class can impact student learning. Class scheduling can result in courses with timetables that are semester-long (aka traditional), accelerated, intensive or compressed. According to Gallo and Odu (2009) an intensive course means that the number of

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weeks over which the course is taken is held constant, but the number of days per week on which the course meets, reduces. In a compressed schedule, the number of weeks per term reduces with a corresponding increase in both the number of hours per day and the number of days per week.

Some studies suggest that 'block' teaching often results in better student concentration and better results than in 'traditional' formats (Grant, 2001; Suzan and Paul, 2008; Warburton and Volet, 2013). It is believed that there is an increase in academic achievement for those students enrolled in a block course (Brett, 1996; Deuel, 1999; Hennebry, 1997; Kirby-Smith, 1987; Wlodkowski and Westover, 1999). Other benefits associated with block/compressed scheduling range from improved morale and increased student satisfaction. As well as the enhancement of the quality of the relationship between student and teacher and more lasting relationships with their peers (Hackmann, 2004; Eineder and Bishop, 1997; Fleming et al., 1997; George, 1997; Hughes, 2004; Canady and Rettig, 1996).

In contrast conducting 'block' courses at undergraduate level raises pedagogical issues relating to time for observation, reflection and long-term content retention (Grant, 2001). It is also suggested that shortened semesters are likely to produce less effective learning as many students forget material and are unable to bridge old and new material (Daniel, 2000; Hamdy and Urich, 1998, Kanun et al., 1963; Wolfe, 1998). Queen (2000) and Rettig and Canady (1997) agree that block/compressed scheduling results in learners having difficulty retaining learning. Arnold (2002) added that any increase in achievement resulting from the implementation of a compressed schedule has diminished by the following year. Lawrence and McPherson (2000) conclude moderate negative impacts on academic performance appear in the areas of language arts, mathematics, social studies, and science.

Other studies suggest that there is little or no change in student achievement when alternative scheduling arrangements are provided (Bottge et al., 2003; Dexter et al., 2006; Zepeda and Mayers, 2006). Carroll, (2003) suggests that the retention of concepts, and process and analytical skills decline slightly whereas Trenta and Newman (2002) suggest mixed results.

The concept that block/compressed scheduling impacts on learning have been discussed. The literature identifies strong advocates and critics and most research available shares both positives and negatives. It is evident from the literature that there is no right or wrong answer, which strongly reinforces the need for this study. It is possible to conclude that learners and educators like block scheduling, but do not know or understand how this effects overall student achievement.

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METHOD

A longitudinal quantitative study was undertaken in 2016. The research plan focussed on comparing and contrasting the end of exam results obtained on traditional scheduling and compressed block scheduling. It also reviewed whether gender, age, enrolment status or residency status have an impact on overall student performance.

Data was collected retrospectively by academics and administrators and stored securely for statistical analysis. The results were obtained from the institutional administrative information system (PSoft). No individual identifiers are attached to the data providing anonymity and the study was covered by a robust ethical approval at the appropriate tertiary institution (Bryman, 2008; Mutch, 2005).

Data analysis was completed to determine the relationship between student performances on the traditional block as opposed to student performance on the compressed block. The student performance was evaluated via a longitudinal study and group (course by course) analysis. The final end of course exam results (Year 1 and Year 2) were gathered from 2011 – 2013 for the traditional block schedule, and final end of course exam results for the same courses were gathered from 2014 – 2016 for the compressed block schedule. A sample t-test, was conducted to provide a statistical examination of two population means to examine whether the samples are different (Cohen et al., 2011). A 2x2 independent group design using ANOVA was utilised to examine if any one group benefitted more than another. This analysis examined the variance between groups and results in a *p*-value which is the probability of obtaining the observed effect under a ‘null hypothesis,' which equates to the assumption of ‘no difference in the effect of the intervention between studies' (Higgins and Green, 2011). Table 1 outlines the number of students enrolled in the undergraduate construction courses.

Table 1: Sample size for each course by year and schedule method

	Compressed block schedules				Traditional block schedules			
Course / Year	2016	2015	2014	**Total**	2013	2012	2011	**Total**
1	87	78	82	**247**	48	65	60	**173**
2	91	72	69	**232**	64	82	70	**216**
3	58	65	49	**172**	53	52	65	**170**
4	51	46	55	**152**	62	60	64	**186**
5	67	80	63	**210**	65	68	71	**204**

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RESULTS AND DISCUSSION

Means and standard deviations of the variables can be seen in Table 2. There was a 53% increase in enrolment in the 2014-2016 period. The enrolment numbers increased over 200% for students of a traditional age, with a nominal (1.6%) increase in adult students. There was a 30% increase in the male cohort, with a 54% increase in female students (over the three-year period). With regards to enrolment status, there was a 36% increase in the number of full-time students with an increase of 26% for part-time students. 25% of the increase was a result of domestic enrolments, with an international student body increase of 60%.

Table 2: Descriptive statistics for all data

		GPA*		End of Course Exam	
	n	**µ**	**Std. Dev.**	**µ**	**Std. Dev.**
Full sample	1635	3.15	2.79	59.55	19.87
Traditional Schedule (2011-2013)	644	3.08	2.87	58.48	21.07
Compressed Schedule (2014-2016)	991	3.19	2.73	60.25	19.02
Males / Traditional	549	3.10	2.87	58.47	21.19
Males / Compressed	784	2.97	2.67	58.87	18.92
Females / Traditional	95	2.92	2.86	58.50	20.36
Females / Compressed	207	4.05	2.80	65.40	18.53
Less than 25 / Traditional	136	2.65	2.64	56.28	19.89
Less than 25 / Compressed	475	1.72	2.29	51.80	2.29
Adults / Traditional	508	3.19	2.91	59.07	21.33
Adults / Compressed	516	3.23	2.73	60.47	2.73
Full-time / Traditional	546	3.02	2.83	58.64	20.20
Full-time / Compressed	858	3.31	2.72	61.32	18.26
Part-time / Traditional	98	3.38	3.06	57.56	25.38
Part-time / Compressed	133	2.43	2.71	53.15	22.22
Domestic / Traditional	530	3.43	2.91	60.67	21.09
Domestic / Compressed	707	3.51	2.76	62.27	18.92
International / Traditional	114	1.45	1.95	48.27	17.68
International / Compressed	284	2.40	2.48	55.25	18.35

The results indicate an average GPA of the full sample (n = 1635) was 3.15 (C+). The subgroups with the highest GPAs were females on the compressed schedule with 4.05 (B-). Followed by domestic students on the compressed schedule with 3.51 (C+), students enrolled part-time on the traditional schedule with 3.38 (C+). As well as adults enrolled on a compressed schedule with 3.23 (C+).

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It is interesting to note that the GPA of International Students enrolled on the traditional schedule scored an average GPA of 1.45 compared to those on the compressed schedule with 2.40.

The end of course exam results (see Table 3) for traditional scheduling (N=637) averaged 58.57% (s = 20.97%) over the period 2011-2013. A marginal improvement can be reported for the end of course exam results for compressed scheduling (N=976) averaged 60.3% (s = 18.95%) over the 2014-2016 period (Table XY).

Table 3: Comparison of end of Course Exam results for each scheduling method

Traditional Scheduling		**Compressed scheduling**	
Mean	58.57	Mean	60.31
Standard Error	0.83	Standard Error	0.61
Median	60.00	Median	62.00
Mode	0.00	Mode	50.00
Standard Deviation	20.97	Standard Deviation	18.95
Sample Variance	439.75	Sample Variance	358.93
Range	100.00	Range	100.00
Minimum	0	Minimum	0
Maximum	100	Maximum	100
Count	637	Count	976
t		-1.723	
p		0.085	

Given the findings of this ANOVA comparison test students in compressed scheduling appear to score at a higher level compared to students on the traditional schedule although not at a statistically significant level. To test for the above, a range of null hypothesis were used. After reviewing each, the data for each course and performing ANOVA computations for each course on both schedules, there were some common themes that emerged. After a t-test comparison the results indicated a significant difference in mean scores in three of the five courses, see Table 4.

Table 4 summary of t-test results

Course	**t-value**	**p-value**	**Conclusion**
1	-0.02197	.982486	The result is not significant at p < .05
2	-1.43967.	.150667	The result is not significant at p < .05
3	-2.30676.	.021671.	The result is significant at p < .05.
4	2.67397.	.007874.	The result is significant at p < .05.
5	-2.9883.	.002959.	The result is significant at p < .05.

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The results for course 5 are considered to be extremely statistically significant; course 4 are considered to be very statistically significant and course 3 are considered to be statistically significant. This indicates that changing from traditional scheduling to compressed scheduling was a positive move for these three level 6 course.

The findings suggest that concerns associated with offering courses or providing alternative teaching pedagogies associated with traditional and compressed scheduling are unfounded. The outcomes are consistent with the literature and support the proposition that a similar student-learning experience is achieved in traditional and compressed courses. The findings that females perform better in a compressed schedule as opposed to a traditional schedule warrants additional study.

One could argue that the marginal increase in end of course exam results was related to the fact that students only had to remember the subject matter for 8 weeks rather than 16 weeks. If this is a possible explanation, it does not bode well for long life learning or retention of the subject matter. Continued review and reinforcement of content learned in earlier courses could overcome this.

CONCLUSION

The aim of this study was to establish if there was a difference in student performance as measured by the end of course exam results based on traditional scheduling or compressed block scheduling. The literature suggests mixed reviews on the success of alternative scheduling methods generally. There is indecision on which scheduling method works best. Most of the research conducted discussed the characteristics (positive and adverse) of scheduling methods but very little compared the move from a traditional schedule to a compressed schedule while analysing student achievement results on standardised tests/exams, incorporating gender, age, enrolment status and residency status.

The data from this study provides some answers about the impact of scheduling on end of course exam results and a snapshot of achievement about gender, age, enrolment status and residency status in a New Zealand context. Although the study examined only one undergraduate programme of study over six years, it is believed that the study could be replicated in other contexts to test the generalizability of the findings. Further research into the performance of students and scheduling would be valuable in both a New Zealand context and globally.

The purpose of this study was to add to the educational research available and expand the information in the area of scheduling and the effect it has on the end of course exam results. It was not possible to identify which schedule type is better and this warrants further research.

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CONSULTATIVE DESIGN AS AN APPROACH TOWARDS SOCIALLY SUSTAINABLE RESIDENTIAL AGED CARE

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ABSTRACT

Currently residential aged care (RAC) provides a solution to address ageing populations in many developed countries. Demand for RAC is predicted to increase as populations continue to age with the recurrent costs posing an increasing burden on society. The contribution the built environment can play to mitigate this potential burden is becoming increasingly important in the design and construction of RAC facilities. The theories of environmental psychology rationalise the relationship between the physical environment and the individual and impacts work stress/satisfaction. Work stress/satisfaction in RAC facilities has a direct influence on quality of care and can directly affect the residents' quality of life. This paper reports on a two stage study of design influences with the potential to impact upon the care team's work stress/satisfaction in RAC where the benefits of consultative design are indentified. When compared to other facilities in the study the facility utilising a consultative design approach demonstrated more positive and less negative results for the design influences included. The consultative design approach reduced the potential for designers to copy and adapt a previous design, afforded universal ownership of the facility and optimised the building's impact on work stress/satisfaction. The approach formed the basis of an overarching process to ensure the necessary elements of the design influences framework can be appropriately incorporated into the built environment.

Keywords: residential aged care, design, consultative.

INTRODUCTION

Many developed countries are currently experiencing ageing populations as a result of a combination of circumstances (Alimoglua & Donmezb, 2005). Currently residential aged care (RAC) facilities, provide a common solution to the problem. RAC facilities are purpose built or adapted buildings which, in Australia, comply with the National Construction Code (NCC) Classification 9c to accommodate aged persons with varying degrees of

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incapacity who are provided with nursing care, personal care and 24-hour staff assistance to evacuate the building during an emergency. However, as demand for RAC surges with the ageing population the initial and recurrent costs may become an increasing burden on society. The contribution the built environment can play to mitigate this potential burden is becoming increasingly important in the design and construction of RAC facilities.

The care is provided in RAC facilities by the "Care Team" consisting of a Registered Nurse, sometimes an Enrolled Endorsed Nurse and a body of Assistants in Nursing who carry out the day to day care procedures. The care team in RAC facilities are faced with a distinctive and specific set of circumstances including exposure to death and dying, working with cognitively impaired residents, coping with challenging behaviours, engaging in long term relationships with vulnerable residents and sometimes conflicting ideals between work responsibilities. These circumstances can result in a challenging and demanding role for the care team who provide for the needs of the residents (Edvardsson, Sandman, Nay, & Karlsson, 2009).

The theories of environmental psychology rationalise the relationship between the physical environment and the individual (Aspinall, 2001). The interaction determines the role the physical environment plays in the contribution to stress or satisfaction. In a RAC work environment work stress/satisfaction can contribute to stress related work absences and staff turnover (Sinoo, Hoof, & Kort, 2011) which impose a financial burden on the RAC organisation and the wider community.

Individual perceptions influence work stress/satisfaction resulting in varying effects on people. For example some sounds may represent noise to some individuals but are not noticed by others (Aspinall, 2001). This aspect forms a challenge when designing a RAC facility with optimal impact upon the care team's work stress/satisfaction.

Work stress/satisfaction in RAC facilities has a direct influence on quality of care (Hannan, Norman, & Redfern, 2001) Frail, cognitively impaired residents rely heavily on the efforts of the Care Team (Castle, 2007). Higher levels of work stress can negatively impact upon the quality of care where higher levels of work satisfaction can increase the level of care and can advance the residents' quality of life.

The aim of this paper is to report on the benefits of consultative design identified within a previous two stage study of design influences with the potential to impact upon the care team's work stress/satisfaction in RAC. In reporting the previous findings the question of whether the consultative design process can be accommodated in the design process and if the consultative design process could provide an approach to providing more socially sustainable RAC facilities will be addressed. The objective of this

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paper is to demonstrate an alternative model for the design process to optimise facility design and provide opportunities to address work stress/satisfaction to address the “environmental fit” (Vischer, 2007) of facility users.

When viewed in the context of an ageing population with the associated economic, social and environmental implications allied to the impact on quality of care and the potential effect on quality of life in RAC, it would appear reasonable to design facilities with optimal impact upon the work stress/satisfaction of the Care Team.

LITERATURE REVIEW

RAC facilities provide unique design problems (Bakker, 2000) which should be approached on an individual basis to provide optimal solutions (Spanbroek, 2005). The design of a facility commences with a brief from the client and is interpreted by the facility designer as it progresses through the design process where design problems are resolved resulting in an optimal overall solution (Brawne, 1992).

The pre-design phase of a construction project commences with the client brief and is the period in the project cycle where approximately 80% of the costs are determined (Tzortzopoulos et al., 2006). This phase underpins the balance of the project and can be the source of project success or problems (Smith et al., 2001).

Lam, Chan & Chan (2010) found that the quality of the client’s brief had a major impact on the success of the project with the development of the brief having the potential to impact project time, cost and quality with client organisations being perceived as having the most influence over the development of the brief (Othman et al., 2005). The brief communicates the client and stakeholder needs to the designers (Smith et al., 2001) and therefore clear identification of the requirements is a prerequisite to project success as there are many influences that can shift the focus of the brief (Yu et al., 2008). A major influence can be the designer’s interpretation of the brief in terms of their own personal experience, values, beliefs and perceptions whereby the resultant design fits their knowledge, expertise and experience (Restrepo & Christiaans, 2004).

The methods used to create a design can vary between designers and one designer may also use more than one method simultaneously to arrive at a solution (Gray & Hughes, 2001). Two of the major methods are outlined in this paper.

Analysis – synthesis - evaluation

The Royal Institute of British Architects (RIBA) (1980) summarises the design process into four phases being i) Assimilation, ii) General Study, iii)

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Development and iv) Communication. These four phases are reliant on the design problem and are not always in this sequence however, commencement is phase 1 and completion is phase 4 (RIBA, 1980).

This design process is supported by Lawson (2005) who argues that the process of increasing detail to meet the design brief involves i) analysis, the understanding and structuring of the problem, ii) synthesis, the creation of a number of possible solutions and appraisal , iii) appraisal the evaluation of the solutions before a decision can be made and iv) decision. (Lawson, 2005).

Generator – conjecture - analysis

In 1978 Jane Darke was investigating the image building designers had of the building user's expectations. In the course of the investigation it was found that the analysis-synthesis design process was not broadly used in practice. Darke (1978) found that building designers often adopted an idea early in the design phase and then attempted to manipulate the idea to work and go some way to solve the design problem. This system narrowed down the range of possible responses to the design problem and enabled designers to focus on a rapid solution, Darke adopted the term "*primary generator*" and described the system as "generator – conjecture – analysis" (Darke, 1979). Selection of the primary generator is based on the architect's subjective judgment or intuition (Rowe, 1987) (Darke, 1979) (Lawson, 2005).

Darke (1979) suggests that building designers often adopt a solution that is cognitively manageable to reduce the number of possible solutions to the design problem before detailed requirements have been worked out. Darke (1979) adopted the term "*primary generator*" and there is support for this idea by researchers like Brawne (1992), Ball, Evans and Dennis (1994) who refer to "*position driven*", Goel (1995) who uses "*early crystallisation*", Eckert & Stacy (2000), Cross (2001) refers to "*solution fixation*", Restrepo & Christiaans (2004) who use the term "*early representation*", Ball and Ormerod (2000) use "*early fixation*" and Visser (2006) who refers to "*design kernels*". These terms are used to describe the practice of selecting a design concept early in the design process and then adjusting and adapting that concept to the point where it has a fit with the design brief (Visser, 2006).

RESEARCH METHOD

The impact of consultative design in RAC was identified in a previous larger two stage study of design influences with the potential to impact upon the care team's work stress/satisfaction in RAC (Hilaire, 2016). Stage 2 of the previous larger project included a multi-case study of existing RAC facilities where the care team, managers and designers of each facility were interviewed in regard to the fit of the facility to the users and work

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practices. The RAC facilities in the previous larger study were selected from facilities designed post the Aged Care Act (1997) where management had responded to an invitation letter. Additionally the participants from the management team and the design team, present during the design process needed to be available. Participants from the care team comprised volunteers from within the facility. Semi-formal structured recorded interviews were conducted with participants from three groups in each case comprising management, care team and the designers. The interviews sought to investigate the participants experience and perception in regard to a number of "design influences" identified in literature and confirmed in Stage 1 of the previous larger project. Data analysis included coding and thematic analysis of the qualitative interview scripts assisted by the use of appropriate software. One case (Case 2) stood apart from the others as having significantly less negative comments and a greater number of positive comments regarding the design influences. Furthermore, all three groups interviewed for Case 2 (care team, management and designers) claimed ownership of the facility design. Firstly a review of the literature concerning the design process was undertaken. Principles and practices of the design process were then identified and reviewed in the context of Case 2. This paper focuses upon the design process for RAC facilities with a discussion of consultative process for Case 2 and the description of a model to integrate the beneficial aspects of the consultative 2 design process.

RESULTS

The process of design used for Case 2 was very different to the design processes used for the other facilities in the previous larger study. The designers of the other cases in the previous study freely admitted during the interviews that the facilities were based on adaptions of previous designs. They prescribed to Darke's suggestion that designers do not always carry out a detailed analysis of the design problem and tend to adapt a previous project or parts of a previous project until there is an approximate fit (Darke, 1979). Darke termed this process "premature commitment" and has been further supported by Brawne (1992), Eckert & Stacy (2000), Restrepo & Christiaans (2004) and Visser (2006).

Design Process Facility 2

Whilst undertaking Stage 2, a multi-case study of existing RAC facilities in a two stage study of design influences in RAC (Hilaire, 2016), one case (Case 2) stood apart from the others where the participants from the care team and facility managers provided significantly less negative comments and a greater number of positive comments in regard to the suitability or "environmental fit" (Vischer, 2007) of the facility with users.

An important facet of the design process was flagged in the Case 2 study with all participants related to that facility (care team, managers and designers) taking ownership of the design of the facility from the overall

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layout and external grounds to the internal finishes and decoration. Further investigation revealed a process of consultation with all levels of staff within the organisation took place prior to engagement of a designer.

The Case 2 organisation operated a number of older facilities and a process was established to form a committee with representatives from all areas of operation within the organisation to identify strengths and weaknesses that could be incorporated or avoided in the new facility. This process of consultation involved the election of a representative from each department or area of expertise within the operating facilities, these representatives formed a “Building Committee”. Each “Building Committee” member sought input from the group they represented and the ideas were discussed at committee level. Ideas accepted by the “Building Committee” were then presented to the organisation's Board of Directors were the relevance and inherent advantage of the idea had to be defended. Throughout the consultation and Board approval process the “Building Committee” compiled a design brief which was ultimately presented to the designers. The result of this process lead to compatible positive responses from members of the care team and the organisation’s management, in contrast to the remaining cases in the study, when asked about the origin of the building design concept.

The process of consultation and staff involvement continued into the construction phase with the “Building Committee” electing a subcommittee (known as the “Colour Team”) which included the facility designer and was responsible for the selection of all internal furnishings and colour schemes.

DISCUSSION

This paper deals with the benefits of a consultative design process but in doing so reaches back to the larger previous project which enabled cross case synthesis between projects derived from a process of “premature commitment” (Darke, 1979) and a project which underwent a process of detailed analysis during the design phase (Pati et al., 2012). The larger previous study identified the differences between the two approaches and highlighted a number of major advantages the consultative design process enabled. These advantages are as follows:

i) The lessons learnt from other facilities can be brought to the new facility. Unless a post occupancy evaluations are carried out this information is not available by adapting previous projects,

ii) Information about current work practices or accreditation and certification requirements are up to date. The risk of utilising superseded information is higher by adapting previous projects,

iii) “Premature commitment” could lead to designers not being aware of issues that are counterproductive to staff in their design. An example is the swing of doors into resident bathrooms which in RAC

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facilities should be counter the normal orientation of doors as a resident can fall against the door within a bathroom. Without consultative design these types of criticism have been found to be passed to subsequent projects.

iv) "Premature commitment" could lead to designers not being aware of changed community expectations or assessment requirements. An example is an early requirement for full view of the resident's bed from the corridor. Assessment requirements and community expectations have shifted to respect the resident's privacy and dignity above other issues. Without consultative design these types of criticism have been found to be passed to subsequent projects.

Consultative Design Process

Comparing a consultative design process to the typical design process which can involve a degree of "premature commitment" has exposed three important steps. The three steps form an overarching design process and are shown in Figure 1 with the consultative project design pathway indicated as Scenario 2 where the influence of the care team as the building users can be seen throughout the process. The work stress/satisfaction of the care team is important in RAC facilities as they control quality of care which has been shown to be a major factor in the resident's quality of life (Murphy, 2007). The work stress/satisfaction of the care team also has an impact on social sustainability, reducing the resource footprint of the facility.

Scenario 1 in Figure 1 is included for comparison purposes and indicates the typical design process which includes the ability to adapt previous projects. Scenario 1 illustrates the possibility of care team input on commencement of the process and then habitation of the facility on completion. The dashed red lines in Scenario 1 indicate the path outlined by Brawne (1992), Darke (1979), Eckert & Stacy (2000), Restrepo & Christiaans (2004) and Visser (2006).

The ultimate aim of this overarching process is to provide the opportunity for optimal facility design. The three steps are as follows:

1. Management and Care Team establish specific requirements,
2. Preparation of a detailed and complete design brief which the organisation can confidently defend, and
3. Ensure a process of current project analysis and engagement.

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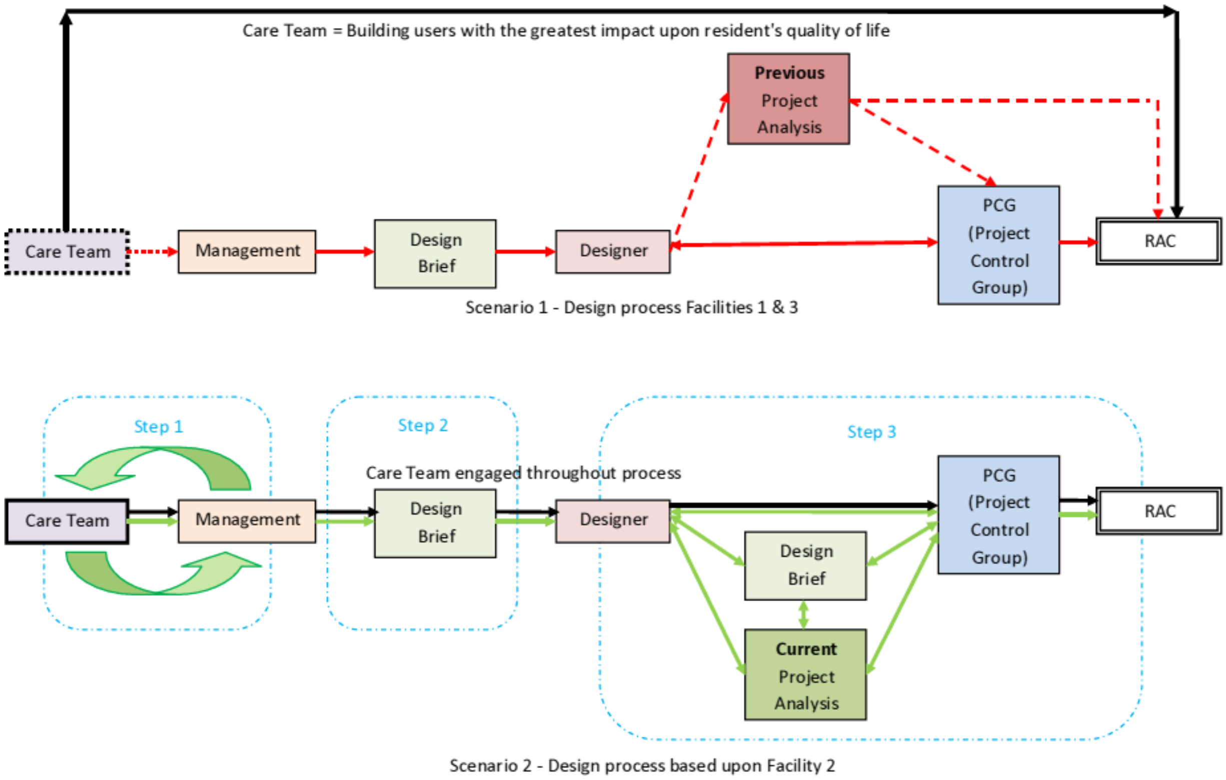

Figure 1 Overarching process to ensure optimal facility design. Scenario 2 shows the consultative design process with three steps required where Scenario 1 is included for comparison purposes.

A discussion of these important steps follows:

Step 1. Establish specific requirements

A wide ranging process of consultation carried out with all project stakeholders before designers are appointed will result in widespread education of all stakeholders in the facility's operations and an understanding between the diverse groups (e.g. Care Team, kitchen, maintenance, administration etc) that contribute to an RAC organisation. The suitability of concepts raised during this process will be further confirmed by presentation, defence and approval at the organisation’s board level. The establishment of specific requirements in this way engages a hybrid process of analysis, synthesis and evaluation (Lawson, 2005) and assimilation, study, development (RIBA, 1980). This hybrid process when undertaken by the organisation has been shown to establish a strict range of specific requirements for a new facility leading to a more definite brief. The understandings and confidence gained from this process serves to underpin the ensuing steps in the project delivery.

Step 2. Preparation of a detailed and complete design brief that the organisation can confidently defend

The widespread process of consultation, analysis, justification and evaluation with all levels of staff within the organisation enables building

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users to take ownership of the design of the facility (Jensen, 2011; Nutt, 1993) and have a confidence that their design incorporates the optimal design solution of the time. With Case 2 in the wider study, the process enabled two very important eventualities:

i) the process enables a complete and detailed design brief which serves to remove many grey areas in the design (Smith et al., 2001), and
ii) the confidence and knowledge that the whole organisation has selected particular aspects of the design should reinforce the determination of the organisation's representatives on the design team to ensure the carefully selected aspects are included in the design (Chandra & Loosemore, 2011).

This second aspect is important and goes towards eliminating the argument from both designers and stakeholders that they have been ignored by the other (Bakker, 2000; Bogers, Meel, & Voordt, 2008) With Case 2 the confidence gained by the process adopted in Step 1 served to underpinned Step 2 and empowered the organisation's representatives to ensure the specific requirements identified as necessary for the facility were incorporated into the project design.

Step 3. Ensure a process of current project analysis and engagement

The third critical step is to avoid the model described by Darke (1979) and other authors like Restrepo & Christiaans (2004) Visser (2006), Ball and Ormerod (2000), Ball, Evans and Dennis (1994), Goel (1995) and Cross (2001) as "generator - conjecture - analysis" or a derivation thereof. The model reduces analysis and evaluation in the design process to a somewhat limited range based on recent projects. The "generator - conjecture - analysis" model has been associated with perpetuating several inappropriate and untested aspects of RAC facility design (Hilaire, 2016). Again the experience with Case 2 saw the circumvention of the "generator - conjecture - analysis" route which was assisted by the confidence provided by the wide ranging process of consultation involving all levels of stakeholders. The consultative process culminated in approval by the Board of Directors and thus the organisation's representatives on the design team were empowered to insist on alternative solutions to design problems which enabled the design team to analyse, synthesis and evaluate the optimal proposition to satisfy the detailed design brief.

CONCLUSION

This paper has reported on the influence of consultative design in RAC which was identified in a larger two stage multi case study of design influences in RAC. The process of consultative design has been shown in

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Case 2 of the previous study to address stakeholder requirements providing widespread acceptance of the facility and thereby providing a step towards optimising the care team's work stress/satisfaction. Work stress/satisfaction in RAC has been shown to have an impact on quality of care which in turn has the potential to have an effect on the quality of life of residents and address aspects of social sustainability.

Incorporating consultative design into the design process in RAC has demonstrated an ability to incorporate stake holder requirements thereby providing the opportunity to:

- i) Apply experiences from other facilities to the new facility,
- ii) Update facilities to accommodate current work practices or accreditation and certification requirements,
- iii) Reduce the instance of incorporating issues that are counterproductive to staff in the facility design, and
- iv) Remain abreast of changed community expectations and/or assessment requirements.

Consultative design has been shown to provide opportunities that reduce the instance of various forms of "premature commitment" whilst affording a greater chance of the built environment satisfying user requirements by enabling:

- i) An accurate brief,
- ii) Confident administration of the brief from the building owner's side, and
- iii) Ongoing detailed analysis of requirements.

To achieve the objective of this paper an alternative model for the design process to optimise facility design has been presented. This model reduces the reliance on design conjecture or "premature commitment" (Darke 1979) and incorporates the opportunity for facility stakeholders to address work stress/satisfaction and adjust the facility to improve the "environmental fit" of facility users (Vischer, 2007). Improvement of the environmental fit has the potential to benefit all stakeholders within the RAC environment.

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SEASONAL USAGE PATTERN OF OUTDOOR SPACES IN EDUCATIONAL PRECINCTS

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ABSTRACT

Sustainable open spaces in cities can enhance humans' day to day life. Among the determinants of the quality of outdoor environments, high priority is given to ambient climatic conditions. This research is aimed to explore the usage pattern of outdoor spaces in an educational precinct and discover its linkage to thermal conditions. The target population was the users of the main open spaces of an educational precinct selected as the case study in Melbourne, Australia. The data collection methods included field survey (questionnaire and concurrent measurement) and unobtrusive observation. The data obtained was used to understand the characteristics of usage pattern in the three seasons (spring 2014, summer 2015 and autumn 2015). The results indicated the seasonal usage pattern of the precinct and the significance of function of the place on people's presence outdoors. The research findings are expected to inform guidelines on managing outdoor spaces, particularly within university campuses.

Keywords: educational precinct, outdoor thermal comfort, field observations, questionnaire survey, usage pattern

INTRODUCTION

Sustainable open spaces in cities can enhance humans' day to day life. Among the determinants of the quality of outdoor environments, high priority is given to surrounding microclimatic conditions (Mayer and Höppe, 1987). Microclimate conditions govern the number of attendance and the quality of activities performed in an outdoor space. Due to social, environmental, and financial reasons, the study of usage pattern has become a central agenda in many urban studies and particularly related comfort (Thorsson et al., 2004, Lin et al., 2013). Some studies have found that there is a link between thermal conditions and use of outdoor

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spaces (Gaitani et al., 2007, Martinelli et al., 2015). For instance, Gaitani et al. (2007) argued that thermal conditions through people's thermal perceptions determine attendance and human activities in outdoor spaces and the level of activities depends on the extent of satisfaction. In contrast, some studies have proved the independence of usage pattern on thermal conditions (Thorsson et al., 2007, Zeng and Dong, 2015), where the use of certain public places was found to be less correlated to thermal conditions. For instance, Thorsson et al. (2007) found that function of places was the determinant of people's attendance in public spaces of Japan. In this regard, Lin (2009) indicated that "…*simple thermal environmental factors or thermal comfort indices cannot fully explain the influence of the thermal environment on the number of people using public spaces and other non-thermal factors ought to be taken into account*" (p. 2025). Therefore, this study is aimed to understand the characteristics of usage pattern in open spaces of an educational precinct in Australia, stressing the relationship with seasonal changes.

METHODOLOGY

Data collection methods

The usage pattern in the open spaces of an educational precinct was investigated. Three types of data collection methods were employed: questionnaire survey, unobtrusive observation and concurrent measurements. Field measurements recorded the values of four major microclimatic parameters: air temperature (T_a), wind velocity (V_a), relative humidity (RH) and globe temperature (T_g). Furthermore, the local microclimatic conditions were acquired from the Bureau of Meteorology (BOM) local weather station throughout the study period for the study area, Melbourne's CBD. In each season, 15 days were allocated to conduct field surveys and observations: from 9:00 am to 5:00 pm in November 2014 (spring), February 2015 (summer), and May 2015 (autumn). The method used in this study is a standard practice to assess outdoor thermal comfort that has been adopted in previous studies (Spagnolo and de Dear, 2003, Thorsson et al., 2004).

Thermal comfort index

One indicator for assessing the effect of weather conditions in outdoor space is the concept of thermal comfort. Thermal comfort is defined as "*…that condition of mind that expresses satisfaction with the thermal environment*" (ASHRAE 55, 2010, p. 7). Two models underpin the thermal comfort criteria that dominate comfort research: the steady state heat-balance theory model (Fanger, 1970) and the adaptive models (de Dear

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et al., 1997). This study drew on the heat-balance theory and assessed the collective effect of four environmental parameters (T_a, RH, V_a and T_{mrt}) and two personal factors (level of clothing insulation and activity) on outdoor users. The Physiological Equivalent Temperature (PET) was used as thermal comfort index. PET is built up on the basis of Munich Energy-balance Model for Individuals (MEMI) in 1987 and is technically linked with the Gagge's two-node model parameters (Höppe, 1999). PET values were calculated using Rayman Software Package 1.2 that assumes constant values for the level of activity (80 W) and clothing insulation (0.55 Clo for spring, 0.41 Clo for summer and 0.81 for autumn). Mean Radiant Temperature (T_{mrt}) was also calculated to be input into Rayman software using T_a, T_g and V_a (ISO 7730, 2006).

Study sites and target population

This study was conducted in the context of Melbourne, which has an oceanic temperate climate (Cfb). Melbourne is known for its unpredictable weather conditions where one may experience totally different microclimate conditions from one day to the next (Peel et al., 2007). Three sites, which are the premises of the RMIT University City Campus (RUCC), an educational precinct, were selected as the case study sites (Figure 1). Urban precincts are suggested as appropriate options for the Australian capital cities to develop new smart and sustainable spaces (Yigitcanlar et al., 2008). These three sites are the main open spaces in the study precinct attracting the major users to the university outdoor areas. These sites have different urban features that provide platform for investigation of thermal comfort in various local microclimate. These features are as follows:

- Site 1: University Lawn which is used as a recreational space by university students and staff. Due to its compact design, a relatively prevalent form in Melbourne's built up areas. This site contained a number of urban elements including shading devices in a café, timber deck and benches, water features, natural green spaces, and an artificially turfed area which generated varying microclimate conditions.
- Site 2: Ellis Court at RUCC was used for different purposes: as the main passage way to other parts of the campus, and a venue for outdoor activities and social events. This site has a 1302 m^2 area and accommodated a range of urban settings, which potentially created an outdoor space with varying local microclimate conditions. Like Site 1, this site had buildings that were heritage listed by the Heritage Council of Victoria. Due to its particular location, this site was largely frequented by students and staff during teaching hours; it is also partly occupied by them in break times.
- Site 3: RMIT A'Beckett Urban Square was a 2800 m^2 recreational project, which provided multi-functional courts for outdoor activities, spare modern green spaces, and shading features. This site resembled many

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commercial outdoor settings in Melbourne's inner city and was designed to serve a wide range of users, mainly university students, staff and other visitors. A few restaurants and cafés were near this site on Stewart Street.

Site 1 Site 2 Site 3

Figure 1. View of outdoor usage in the three study sites.

The study population consisted of university students, staff and others using these spaces at the time of surveys. The administration of the field surveys was approved by the RMIT University Human Research Ethics Committee.

RESULTS & DISCUSSION

In total, 1059 questionnaires were collected over the three study seasons: spring (368), summer (413) and autumn (278). Furthermore, during 18 days of unobtrusive observations, 267 sets of data about usage characteristics was gathered in spring (102), summer (90) and autumn (75). The following sections present the results of analysis applied on the data obtained in these field surveys. The results suggest how various seasons may cause changes usage in pattern in outdoor spaces.

Weather conditions

The weather conditions of the study area, Melbourne CBD, in the seven months and within the three seasons, collected from the nearby BOM's weather station are presented in Table 1. The results indicated that T_a in summer was larger compared to that in spring and autumn. The mean maximum T_a in the last month of summer (February 2015) was greater than that in the last month of spring (November 2014) and autumn (May 2015) by 3.6 °C and 8.2 °C, respectively. Correspondingly, the highest monthly mean global solar exposure was observed in summer; this was registered as 14.4 $M.Jm^{-2}$, 24.2 $M.Jm^{-2}$ and 16.7 $M.Jm^{-2}$ in September, December and March, respectively. The values of RH and V_a were relatively similar over the period as presented in Table 1.

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Table 1 Summary of monthly Melbourne's CBD mean climate conditions. Source: BOM's local weather station.

	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
Air temperature- T_a (˚C)	13.7	15.7	17.2	18.6	20.3	20.9	17.6	14.6	13.2
Mean. Max-T_a (˚C)	14.3	16.3	17.9	19.3	21	21.5	18.2	15.1	13.7
Mean. Min-T_a (˚C)	13.1	15	16.6	18	19.7	20.3	17	14.1	12.7
Relative humidity-RH (%)	68.6	65.2	61.9	68.2	64.5	67.6	63.3	73.1	71.1
Wind velocity-V_a ($m.s^{-1}$)	3	3	2.8	2.8	3	2.6	2.5	2.2	3
Monthly mean global exposure ($M.Jm^{-2}$)	14.4	18	22.2	24.2	24.6	21.4	16.7	11.3	7.6

The measurements of two environmental variables (RH and T_a) indicated that study sites had similar microclimate conditions throughout the study period with maximum difference of 2.8% (RH) and 0.9 ˚C (T_a) in summer.

Frequency and purpose of visit: by season analysis

To assess the characteristics of usage pattern, the "frequency of use" and "purpose of visit" by participants were elicited in different seasons. Results showed that with change in seasons and drastic decrease in temperature, the number of people who often (daily to several times a week) used the open spaces noticeably reduced (Table 2), from 52.4% in spring to 37.8% in autumn. The category of "daily to several times a week" was found to be the main frequency of visits among the study population. The results also suggested that seasonal change was not an important determinant of purpose of visit among the study users. Generally, two categories including "having break, resting, change of environment" (>30%) along with "getting fresh air" (>17%) were the main purposes of visits during the study seasons.

Table 2. Summary of seasonal statistics of frequency and purpose of visit

		Spring		Summer		Autumn	
		N	%	N	%	N	%
Frequency of visit	Daily to several times a week	193	52.4	212	51.3	91	37.8
	A few times a week	74	20.1	97	23.5	92	38.2
	A few times a month to rarely	76	20.7	64	15.5	45	18.7
	First time	25	6.8	40	9.7	13	5.4
Purpose of visit	Having break, resting and change of environment	186	37.3	191	31.4	120	30.4
	Getting fresh air	94	18.8	105	17.2	77	19.5
	Playing	10	2.0	38	6.2	26	6.6
	Passage to another place	76	15.2	98	16.1	57	14.4
	Having lunch/snack	78	15.6	101	16.6	54	13.7
	Read/write	17	3.4	21	3.4	19	4.8
	Meeting/waiting for someone	38	7.6	55	9.0	42	10.6

Table 3. Summary of statistics of length of stay and type of users

		Spring		Summer		Autumn	
		N	%	N	%	N	%
Length of stay	Less than 5 minutes	141	38.4	167	40.7	131	47.3
	5- 10 minutes	98	26.7	130	31.7	56	20.2
	10-30 minutes	73	19.9	71	17.3	56	20.2
	More than 30 minutes	55	15	42	10.2	34	12.3
Type of use	Transient	108	20.7	225	30.4	245	40
	Non-transient	263	79.3	739	69.6	717	60

Length of stay and type of users

Length of stay and type of users (transient vs. non-transient) were also assessed using questionnaire survey and unobtrusive observation, respectively. The results indicated that those who stayed outdoor for a few minutes and non-transient were the major users (Table 3). In spring, a larger number of people stayed for longer time (34.9%) than those in summer (27.5%) and autumn (22.5%). The percentage of transient users increased from spring (20.7%), to summer (30.4%) and to autumn (40%). These results together proved that seasonal changes and thermal conditions influenced the usage characteristics of outdoor spaces.

Thermal adaptive measures and type of activities

Strategies that participants may take in response to adverse outdoor weather conditions were also investigated using a multiple-choice question in the field surveys. The results indicated that people considered relatively different thermal adaptive measures in various study seasons (Table 4). For instance, moving to shade/sunlight was accounted for 45.2% of total adaptive measures in summer, 37.1% in spring and 25.2% in autumn. Furthermore, given that adding/reducing clothing correspond to 45% of total votes in autumn (44.8%), it can be argued that in outdoor spaces, “move to shade” and “adding to clothing” were the main adaptive strategies adopted in confrontation with adverse weather conditions in hot and cold seasons, respectively. The field observations indicated that in general, resting/talking in two postures (sitting/lying down) accounted for most of the activities in different seasons (Table 4). However, different seasons influenced the frequency distribution of type of activities in the study sites. In summer and spring, around 60% of people tended to rest and talk in sitting and lying positions, whereas in autumn, only 31% of them preferred these positions and about 27% took the standing posture in the study open spaces.

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Table 4. Summary of seasonal statistics of thermal adaptive measures and type of activity

		Spring		Summer		Autumn	
		N	%	N	%	N	%
Adaptive measure	Use umbrella/hat	46	10.7	44	9.2	12	4.2
	Move to shade /sunlight	159	37.1	217	45.2	72	25.2
	Reduce/add clothing	149	34.7	100	20.8	128	44.8
	No change	66	15.4	115	24.0	69	24.1
	Others (please specify)	9	2.1	4	0.8	5	1.7
Type of activity	Smoking	4	5.3	4.5	1.4	10.5	12.0
	Eating/drinking	14	18.4	47.5	14.7	18	20.6
	Playing	1	1.3	14	4.3	2.5	2.9
	Studying	4	5.3	33	10.2	6	6.9
	Standing	9.5	12.5	43	13.3	23.5	26.9
	Resting/talking (sitting/lying down)	43.5	57.2	182	56.2	27	30.9

Total number of attendance: by-season and by-site analyses

The interaction between usage pattern of study sites and thermal conditions during various seasons was investigated using correlation analysis test. This analysis involves an investigation of people's presence outdoors with reference to both individual and collective effect of environmental parameters. Table 5 provides the summary of findings for the correlation test in all seasons.

Table 5 Summary of correlation between physical parameters and number of visitors in various seasons

		T_g	T_a	RH	S_r	V_a	PET
Spring (N=102)	Pearson Correlation	.202*	.155	-.179	.140	.008	.15
	Sig.	.042	.12	.072	.162	.936	.114
Summer (N=90)	Pearson Correlation	.150	-.047	-.53**	.308**	-.047	.031
	Sig.	.159	.662	.00	.007	.657	.77
Autumn (N=72)	Pearson Correlation	.452**	.638**	-.062	.366**	.234*	0.29*
	Sig.	.00	.001	.607	.002	.048	.011

Note: *correlation is significant at the 0.05 level, **correlation is significant at the 0.01 level, ns correlation is not significant

In spring, it seemed that the number of people attending RUCC open spaces was not statistically associated to PET temperatures (r=0.15, P>0.05) and measured environmental parameters, excluding radiant temperature (r=0.20, N=102, P<0.05). These results, however, did contradict the results obtained for summer and autumn. In summer (N=92), among the monitored parameters, relative humidity (r=-0.53) and solar radiation intensity (r=0.38) had the highest correlation with

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total number of attendance being both significant at the 0.01 level. The results highlighted that among the study seasons, the usage pattern was most influenced by environmental parameters in autumn (N=72), as four out of five variables had a significant correlation with the number of visitors. The highest correlation in this season was found for T_a (r=0.63, P<0.01) and T_g (r=0.45, P<0.01), followed by S_r (r=0.36, P<0.01) and V_a (r=0.23, P<0.05). Overall, these results showed that people's presence outdoor was significantly influenced by environmental parameters in different seasons. The results of unobtrusive observations at various times of the day, total attendance in particular, were associated with thermal conditions to explore the impact of "time of day" and "microclimate conditions" on spatial visits. Therefore, the number of attendances was plotted against hours and PET values (Figure 2). To quantify the extent of the link between total attendance and these two factors, a polynomial second order regression was applied to the aggregated data. The results suggested that a strong relationship existed between thermal conditions and people's presence in RUCC open spaces. However, there was a disparity regarding the extent of association within the study sites. As juxtaposed in Figure 2, the usage pattern in Site 1 had a roughly similar association with thermal conditions (R^2=0.71, P<0.01) as to time of the day (R^2=0.67, P<0.01) throughout the study period. In Site 2, there was an opposite circumstance where the effect of thermal conditions on total attendance was weaker (R^2=0.39, P<0.05) than time of the day (R^2= 0.68, P<0.01). The former association was also found to be the weakest among the study sites. Similar to Site 2, the number of visitors in Site 3 was more governed by the time of the day (R^2= 0.83, P<0.01) than thermal conditions (R^2=0.61, P<0.01). The results reflected the role of space function along with thermal conditions in people's usage patterns of outdoor spaces in different seasons.

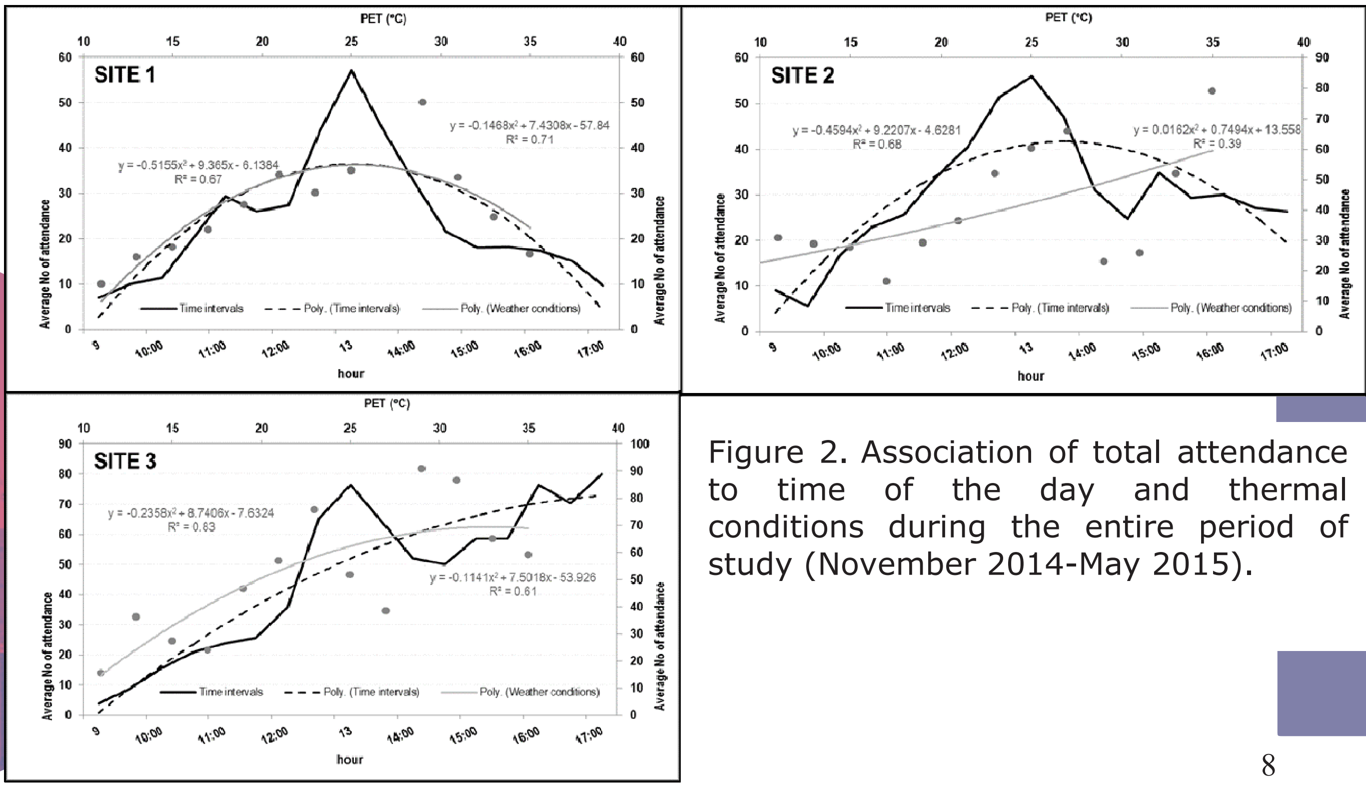

Figure 2. Association of total attendance to time of the day and thermal conditions during the entire period of study (November 2014-May 2015).

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CONCLUSIONS

This study was aimed to investigate a research hypothesis that seasonal changes influence usage patterns of outdoor spaces. Three types of data collection methods (field measurements, questionnaire survey and unobtrusive observation) served to test this hypothesis in an educational precinct. The research findings proved the noticeable impact of three study seasons (spring, summer and autumn) on usage pattern of three open spaces among the university students, staff and other users. The results indicated that seasonal change may influence the frequency of usage, length of stay, type of use, thermal adaptive measures, type of activity and finally number of people's attendance in the outdoor spaces. These results therefore satisfactorily supported the research hypothesis. Further by-site analysis displayed that the function of place along with thermal conditions played a key role in people's attendance outdoors. The research findings are expected to inform guidelines on managing outdoor spaces, particularly within university campuses.

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THE LINK BETWEEN FACILITY MAINTENANCE AND WORK STRESS/SATISFACTION IN RESIDENTIAL AGED CARE

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ABSTRACT

Currently in many developed countries populations are ageing due to a number and combination of circumstances. Residential aged care (RAC) provides a role in addressing the associated need to care for ageing people but the potential for increased demand means RAC providers must look to further efficiencies for sustainability. The care team provides hands on care in RAC and work stress/satisfaction within the care team can be affected by the quality of care and directly impacts the resident's quality of life. The work stress/satisfaction within the care team can also be affected by the built environment. Appropriate design of the built environment can optimise work stress/satisfaction and this paper will propose that maintenance of that environment can also have an impact. This paper will report on a previous study comprising semi structured interviews with care team members and management representatives from a multi case study comprising a number of RAC facilities. Content analysis was carried out on interview scripts. The study revealed facility maintenance was not only important to preserve an asset and reduce hazards, it also revealed facility maintenance to have a bearing on a number of factors which impacted the care team's work stress/satisfaction. This paper will suggest that strategies to improve perceived control of facility maintenance may increase a view of self-worth and go towards optimisation of work stress/satisfaction amongst the care team thus promoting a level of social sustainability.

Keywords: residential aged care, built environment, maintenance.

INTRODUCTION

Currently in many developed countries there is an amalgamation of circumstances which result in creating ageing populations (Black et al., 2012). The potential demand this may place upon existing systems has been recognised and societies are looking for ways to lessen the approaching impact.

At this juncture the question may be raised as to what influence construction management could have on the impact of an ageing population

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and readers are respectfully directed to the theories of environmental psychology which seek to rationalise the relationship between an individual and the physical environment (Aspinall, 2001). An individual's interaction with the physical environment determines the role the physical environment plays in the contribution to stress or satisfaction (Codinhoto et al., 2009). In a work environment like a residential aged care (RAC) facility, work stress/satisfaction can contribute to stress related work absences and staff turnover (Cameron & Brownie, 2010) which impose a financial burden on the RAC organisation and the wider community.

RAC facilities have a unique and particular set of circumstances including working with cognitively impaired residents, exposure to death and dying, caring for residents with challenging behaviours, engaging in long term relationships with vulnerable residents and sometimes conflicting ideals between the care level and other work responsibilities. These circumstances can result in a demanding and challenging role for the care team (Edvardsson et al., 2009).

Carers (Assistants in Nursing (AIN), Certified Nursing Assistant (CNA), Personal (or Patient) Care Assistants (PCA) or nursing aide) within the care team in RAC provide 80% to 90% of resident care and are thus the "linchpin" to the provision of quality care (Castle, 2007; Proctor et al., 1998) which is a major component of quality of life for many residents (Bowling & Gabriel, 2007; Smith et al., 2012) in RAC. Carers therefore have the greatest potential to affect quality of life for residents (Courtney et al., 2003; Hannan et al., 2001).

Work stress/satisfaction however is influenced by individual perceptions resulting in varying effects on people. For example some sounds may represent noise to some individuals but are not noticed by others (Aspinall, 2001). This aspect forms a challenge when trying to design a RAC facility with an optimal impact upon the care team's work stress/satisfaction.

There are many factors that influence work stress/satisfaction within RAC facilities and this research will investigate the role facility maintenance, as one of the factors, plays in the work stress/satisfaction of RAC building users. Facility maintenance includes any operation necessary to maintain building quality (Australian Government Department of Health and Ageing, 2006; Aged Care Standards and Accreditation Agency Ltd, 2014) and therefore can range from changing a light globe, patching surfaces to replacing major and minor components if necessary to preserve the quality of the facility which, in this context, includes the gardens and outdoor areas.

The aim of this paper is to report on the impact of facility maintenance identified within a previous two stage study of design influences with the potential to impact upon the care team's work stress/satisfaction in RAC. In reporting the previous findings a number of multi faceted links between

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facility maintenance and the care team's work stress/satisfaction are identified which answer the question of whether strategies to improve perceived control of facility maintenance may increase a view of self-worth and go towards optimisation of work stress/satisfaction amongst the care team.

When viewed in the context of an ageing population with the associated economic, social and environmental allied to the impact on quality of care and the potential effect on quality of life in RAC, it would appear reasonable to investigate the ways in which maintenance of the built environment impacts upon the work stress/satisfaction of the Care Team in RAC facilities.

RESEARCH METHOD

The influence of facility maintenance in RAC was identified in a larger two stage study of aspects of the built environment with the potential to impact upon the care team's work stress/satisfaction in RAC. Although not initially included in the larger project, facility maintenance was identified by a number of participants in Stage 1 of the project and was therefore included in Stage 2 which included a multi-case study of existing RAC facilities designed post the Aged Care Act (1997). The case studies included participation of the care team and managers of each facility in informal interviews where their experiences and perceptions were investigated in regard to the potential of facility maintenance (along with several other aspects of the built environment) to impact upon the work stress/satisfaction of the care team. Data analysis included coding and thematic analysis of the qualitative interview scripts assisted by the use of appropriate software. (Hilaire, 2016).

RESULTS

During Stage 1 of the project comments about facility maintenance were raised by 11% of participants. The comments indicated a number of perspectives, the most common being that the level of facility maintenance can be interpreted as a reflection of the importance the organisation places on the facility and thence by association the workers within that facility. The perception of inadequate maintenance has been indicated with comments like "*I don't like the fact that it's in a bit of disrepair, you'd think that after spending millions on buildings they would keep it all nice and that sort of thing. It's starting to get all shabby and that spoils the niceness of it so people lose concentration and ram a wheelchair into a wall and leave a gash, they don't care about fixing the gash and they don't care about us.*" and "*The building is actually falling apart on the outside where we have our smoke breaks. It hasn't been repaired at all, ever so they don't care. They don't care about us either.*".

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The perception of inadequate maintenance also had the potential to contribute to work stress in a second way where participants indicated their desire to care for their work environment could be frustrated. Comments supporting this perception included *"The plasterboard on the walls is falling apart. It gets knocked by beds and stuff especially in dementia and the plasterboard is so crumbly it makes a hole straight away. It worries me they don't fix it but why should we worry if they don't".*

The third major aspect is the concern over the perception of the community and in particular the relatives of residents. This sentiment was expressed as "*The buildings aren't run down and shabby but if they were I would worry about the impression they would make on relatives and people in the community*".

However, on the other side of things good maintenance of an older building received positive comments like, "*I don't really like the building it is old style and I don't like the colours but it has a good maintenance crew and it's well looked after which keeps it neat and nice. It has to look nice, it's their* (residents) *home and it has to look nice for them*."

Stage 1 of the larger project revealed that facility maintenance has several facets with the potential to impact upon the work stress/satisfaction of the care team and supports the measure of facility maintenance success put forward by Chan et al., (2010) where facility functionality includes people factors such as employee perceptions and the ability of the maintained workplace to enhance productivity (Ball & Ormerod, 2000).

The cases selected for Stage 2 of the larger project were in general fairly well maintained facilities and therefore did not offer a direct comparison between a well-maintained facility and a poorly maintained facility. However, there was a comparison between an original facility on one site and the current new facility which replaced it. The original facility was evidently well received by staff and well maintained however when the decision was made to construct a new facility the maintenance ceased. Two of the participants had experienced working in the new and old facility and had therefore experienced i) a well maintained older building, ii) the same older building not maintained, and iii) a new building. These participants explained "*The old building was built in the 1960s, so it's a bit old, it was really nice to be in until they stopped taking care of it, then it just started falling apart.*" and "*towards the end, less money got spent on it and it started to look really dilapidated and it was embarrassing. It didn't matter that it was old when it was well maintained, but when they let it go, it was awful. It was pretty depressing being over there.*". These comments indicate that in this instance the older well maintained facility satisfied these participants however as less maintenance was carried out it became

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"embarrassing" and "depressing" which demonstrates a potential to impact upon work stress/satisfaction in some individuals.

There was accord between the care team and management participants in all cases that facility maintenance could have a positive impact on staff attitudes to work. Comments from care team participants in Stage 2 included "*This building is looked after really well, they* (management) *care about it and want it around and functioning well for a long time, that's a good thing for me*." and "*As soon as we put in a work request it gets fixed, probably within a few days, they* (management) *care about the building and us. Management here is good that way, the last place I worked nothing happened so we didn't bother and in the end I left*." and "*Things get fixed here very promptly, sometimes the next shift you see it has been sorted out, I love it, you know that when you report something you are taken seriously.*".

The management participants were more philosophical about the extent of maintenance and extended the effects through to the residents with comments like "*Maintenance also flows through to the people that work here, if you don't maintain the building then the people who work there think if they don't care about the building then they don't care about us so why should we care about the building and it flows through to the residents. It can become a vicious cycle*." A sentiment expressed by the care team was also echoed by the management participants. A prompt response to a staff request for maintenance produced a beneficial effect on the staff, comments supporting this include "*Staff feel good if they report something for maintenance and it is fixed pretty soon, they feel acknowledged and that we have recognised they do exist and what they say is important. If they got ignored they would start to feel they were not important*".

The management participants were quite open about the cost but also pointed to what they perceived to be the resulting benefits. Comments supporting this idea included "*Aged care organisations have to publish their financials so we know that we spend more on maintenance, which includes landscaping, than any of the top 25 ……. Building maintenance for us is extremely important, a lot goes into the gardens but that feeds back into the resident and staff's view to the outdoors so that people have something well maintained and good to look at. This goes towards quality of life for the residents and also greatly helps the staff*" and "*The monetary values don't take into account all the benefits, it absolutely impacts on staff, it shows that we care for the building and we then automatically care for the residents and the staff.*". The management participants from one facility explained that their outlook on maintenance came from experiencing the benefits at the sister facility which is an older building. Comments included "*It is a good example of where we used our experience from another facility and applied it here, we believe maintenance has an impact on the resident as well, they think if they don't care about the place, they're not going to*

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care about me either, I think overall it (facility maintenance) *is a great success."*.

Another advantage to effective maintenance was the reduction of potential hazards. This is supported by comments which included "*It* (maintenance) *is very important, we are lucky it is a new facility but it is still very important to have a good maintenance programme running for issues and hazards as they occur*."

The effect of maintenance was very adequately summarised in a comment by a management participant "*Building maintenance has a big psychological effect on the people that work there, the most beautiful building will lose appeal if it is allowed to become shabby*". This comment links perceptions of facility maintenance and attitudes at work to demonstrate the widespread impact of facility maintenance.

DISCUSSION

During Stages 1 & 2 of the larger research project participants identified ways in which their perception of adequate or inadequate facility maintenance impacted on the work stress/satisfaction of the care team.

The participants indicated that facility maintenance has several facets and is not solely a life cycle methodology (Assefa et al., 2007). Maintenance of a facility is a part of the role of Facilities Management (FM) (Tay & Ooi, 2001) however, this research has revealed that the effects can run much further and can also fit within the interdisciplinary field of environmental psychology (Aspinall, 2001) which theorises the relationship between an inhabitant and the environment they occupy (Bell et al., 2001). The research has identified that this relationship is rooted further back in the participant's experience and in some instances their perceptions can be more relevant than reality (Tucker & Smith, 2007). This is borne out in this research by the way participants perceived the importance an organisation placed on facility maintenance was a reflection of the importance that same organisation placed on the care team. Care team participants also noted the importance of a timely response to a maintenance request. This perceived control of facility maintenance may increase the view of self-worth and impact upon work stress/satisfaction amongst the care team (Cooper et al., 2008). The participants also projected the perceptions of the community and experienced embarrassment based on those projected perceptions.

Care team and management participants offered a number of insights into the potential impact upon the work stress/satisfaction of the care team influenced by facility maintenance.

The far-reaching effects of facility maintenance include:

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- The level of facility maintenance can be interpreted as a reflection of the importance the organisation places on the facility and thence by association the workers within that facility,
- Inadequate maintenance could see an erosion of the desire within staff to care for their work environment,
- The perception of the community can be projected by the care team to create a feeling of embarrassment,
- A prompt response to a staff request for maintenance can produce a beneficial effect as staff interpret this as acknowledgement by the organisation,
- Benefits of maintenance flow back to residents who perceive that if management cares for the building then they automatically care for the residents and the staff,
- Address issues and hazards as they occur,
- Inadequate maintenance can be depressing to some individuals of the care team, and
- There is a maintenance – attitude link that can impact the work stress/satisfaction of the care team.

CONCLUSION

In RAC the work stress/satisfaction of the care team has the ability to impact on the resident's quality of life via the influence on quality of care. The theories of environmental psychology recognise the association between an individual and the facility. This research found that the maintenance of the facility forms a part of the relationship between the individual and the facility and has far reaching effects not limited to the traditional ideas of asset preservation and risk reduction. Facility maintenance can play into the perceptions of the care team and can influence their work stress/satisfaction in RAC.

The findings from this research have implications for RAC organisations and facility managers who can realise the impact of facility maintenance for future planning.

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APPLICATION OF RFID IN THE PREFABRICATED TIMBER INDUSTRY

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ABSTRACT

RFID (Radio Frequency Identification) has recently gained significant attention in various industries, whereby a common application of the technology is to gather and transmit real-time information related to inventory control and logistics. This paper develops the case for the use of RFID in the prefabricated timber industry by first examining its application in other industries. From there, the paper presents a framework for the adoption and testing of RFID within the prefabricated timber industry as a method to automate inventory control, logistics, and document control, while optimizing construction duration. The paper presents the methodology for field trials designed to determine potential for RFID applications in the prefabricated timber structure supply chain from raw material production to panel fabrication to shipping and onsite logistics and finally through to construction installation. The methodology will be tested in collaboration with industry partners and Forest and Wood Products Australia.

Keywords: Construction Documents, Prefabricated Timber, RFID, Supply Chain, Timber

INTRODUCTION

Radio Frequency Identification (RFID) technologies, refer to the process of indexing information of physical objects and using radio frequencies to transfer information from the object to interested users. RFID is a form of technology that can be used to automate information systems and supply information using RFID tags (attached to physical objects) and RFID readers operated by users. RFID has recently gained significant traction in various industries, supply chains and logistical applications due to its ability add value and generate cost benefits. Industries that have seen applications of RFID that lead to cost benefits include: logistics and shipping (Ramanathan et al. 2014), retail (Loebbecke, 2005), medical (Chao et al. 2007), and mining (Mahmad et al. 2016).

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The construction industry is notoriously slow when it comes to adopting new technologies. The Global Construction Survey 2016 (KPMG International, 2016) identified that conservatism, as it pertains to the adoption and experimentation with technology, remains the norm in the construction industry, with most firms being content to follow rather than lead. A significant contributing factor to this conservatism is that many senior executives are worried about their organizations' ability to integrate disparate technologies, along with the costs and the subsequent impact upon the bottom line (KPMG International, 2016). Thus, when examining the applicability of technologies such as RFID to the construction industry, it is important to establish the cost benefits. Annual turnover for the respondent companies ranged from less than $US1 billion to more than US$20 billion (KPMG International, 2016). Which would indicate that these firms were in a better place to experiment with technology, yet when it comes to technology innovation, just 8 percent of the respondent organisations fell into the "cutting-edge visionary" category, while 69 percent were considered either "followers" or "behind the curve (KPMG International, 2016)."

Because firms do not feel as though they have the margins that are necessary in order for them to take on the costs and risks associated with being early implementers of new technologies, it is especially important that professional groups and academic researchers collaborate with industry to identify the cost benefits of implementing new technologies. Because of this, Forest and Wood Products Australia, a not-for-profit company that provides integrated research and development services to the Australian wood products industry has assisted the authors and industry partners to undertake research into the potential for RFID to add value in the prefabricated timber construction industry. The initial stages of the research are reported in this paper.

RADIO FREQUENCY IDENTIFICATION

RFID tags attached to a physical object allow a read and write capacity whereby very small amounts of information about the object can be stored on the tag this can be changed by writing new information, such as updates concerning quality control inspection, delivery to a certain location, completion have a defined process and so on. RFID provides wireless communication between tags and readers, which facilitates real-time information management through automated identification processes that don't require the physical examination of items. Using RFID, product data is automatically transmitted by radio signals. The key component of RFID technology is the RFID tag (called a transponder), which is a minute computer chip with an inbuilt antenna. As a tag passes through a radio frequency field generated by a compatible reader, it transmits stored data to the reader, thereby giving details about the object to which the RFID tag is attached. The RFID reader can be a tablet or other device, which can also be connected to the cloud whereby additional information that is generated during a product's time in the supply chain can be accessed or saved. Figure 1 shows the configuration for an RFID system. RFID systems operate in 'free air', i.e. non-regulated frequencies of the wireless communications spectrum.

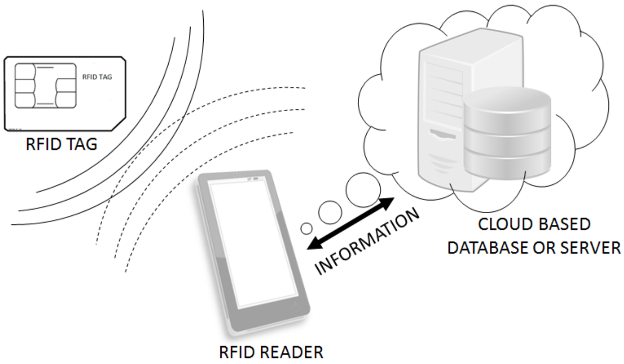

Figure 1: RFID process

RFID has been used successfully in industries including the shipping and logistics, retail, medical, and mining industries in order to generate cost benefits. The broad spectrum of industries benefiting from the use of RFID is indicative of its adaptability to meeting various user needs, including those needs of the timber construction industry. By reviewing past successful applications, a methodology can be created to test RFID's applicability to timber construction industry and collect empirical data related to such an application.

RFID in Logistics and Shipping Industries

In the logistics industry, RFID is used to check the integrity of products and determine if they have been tampered with during transit (Nagabhushana, 2013). RFID technology also serves to increase the flow of containers through shipping ports by speeding up container checking and administrative processes such as paper work. Manual checking of paperwork and filing becomes unnecessary, for the process is automated. RFID is also being used to check specific product parameters (temperature, pressure, and humidity) and to detect the chemical and biological substances within a shipping container (Nagabhushana, 2013).

Lee and Chan (2009) identified that RFID is being used in Reverse Logistics Systems, which assists in situations where customers return products for reuse or recycling. RFID tags can store model numbers and serial numbers of the products, manufacture dates, material information, and names of the retailers and distributors (Lee & Chan, 2009), all of which can be used to assist in the recycling of materials at the end of a product's useful lifecycle.

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RFID in the Retail Industry

In the retail supply chain, manufacturers attach time stamped RFID tags to all products, which are then entered into the central computer of the goods tracking system which will allow both the retailer and manufacturer to track and locate the tagged pallet along the logistic supply chain (Loebbecke 2005). RFID tags have also been used in receiving operations in warehouses. According to Gaukler and Seifert (2007), in a conventional non-RFID process, when receiving a pallet of goods, individual products in the pallet need to have bar codes scanned in order to be entered into the computer system to check the delivered products against orders. For that, a staff member needs to break into the pallet and scan each product. This is both time-consuming and mistake-prone. This scenario can be simplified if the products in the pallet were fitted with RFID tags, then entire pallets simply need to be pulled within range of the RFID reader portal, and from there all products in the pallet would be entered into the retail inventory management system instantaneously. Because of its success in creating cost benefits, the retail sector is currently undertaking the standardisation of RFID through the International Organisation for Standardization (Loebbecke 2005).

RFID in the Construction Industry

According to Razavi and Haas (2011), deficiencies in material management are a common factor hampering construction productivity. These deficiencies may result from lost or damaged materials, unnecessary multiple handlings of materials, required materials not being procured, materials being procured but not received, and out of sequence material deliveries. Elghamrawy and Boukamp (2010) suggest, construction industry is a labour intensive industry with low levels of information integration. Those low levels of information integration could be improved with the use of RFID for materials and tool tracking (Sardroud 2012), document management (Elghamrawy & Boukamp 2010), and providing real-time information. Jaselskis et al. (1995) as cited in Lu et al. (2011).

Hinkka and Tatila (2013) suggest the application of RFID technology in material management applications is easy and simple to adapt. If materials are tagged by the RFID system, then the material tracking management system will provide information about the progress of construction onsite, and materials delivered, by simply walking a site with an RFID reader in-hand. This would give more precise estimates of percentages of work completed and the quantity and quality of delivered goods (Lee et al. 2013).

Song et al. (2006) provide an example using RFID to track materials, wherein scans are performed on a concrete truck from a distance as it passes through a RFID gate to track materials. In addition, the technology has been adapted to automatically track delivery and receipt of

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prefabricated goods as they are dispatched and received through the entry gates on construction sites. According to Lee et al. (2013), an RFID system can create automatic billing upon receipt of materials at job-sites. Demiralp et al. (2012) did a case study and collected data by interviewing practitioners from precast concrete and construction companies and then running simulations on the use of RFID within the supply chain. Based on the simulations Demiralp et al. (2012) calculated cost savings of approximately 3% on projects where prefabricated exterior concrete panels were fitted with RFID tags prior to entering the supply chain. Cost savings in the RFID cases were observed due to: (1) the reduced number of missing panels, and thus the reduced number of remanufactured panels; (2) the reduced number of incorrectly delivered/identified panels, and therefore, the decreased number of transfers; and (3) the reduced durations of some activities, resulting in decreased labour costs (Demiralp et al, 2012).

What can be gleaned from application in both construction and other industries is that the importance of logistics increases as the nature of prefabricated construction causes an inherent change in production processes from manually assembling many small objects onsite, to handling a smaller number of large and value added prefabricated objects, where care is needed in ensuring an efficient work flow from factory to site assembly. Concerning this:

- RFID can track large prefabricated objects with graduated checking of processes that span factory processing, factory storage, delivery logistics, installation sequencing, insitu placement and quantification of work complete for progress and billing.

- RFID can read through multiple layers of construction thus allowing retrospective checking of objects encapsulated within the construction. If used in conjunction with a holistic quality assurance system compliant with ISO 9000 (International Organization for Standardization [ISO], 2015), there is potential for it to be used as part of an information gathering, inspection and compliance regimes for prefabricated construction elements installed onsite.

APPLICATION OF RFID TO THE PREFABRICATED TIMBER CONSTRUCTION IDUSTRY

After reviewing the literature related to the use of RFID in order to achieve cost savings, the authors have identified that the prefabricated timber industry could benefit from the implementation of RFID in the supply chain to track the manufacture, delivery, and installation of large prefabricated timber panels such as floor/roof cassettes or large Cross Laminated Timber (CLT) panels, which are becoming increasingly common

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as part of prefabricated construction solutions. The authors propose the following:

- Stages of timber panel fabrication can be monitored using RFID and provide accurate tracking of fabrication duration stage completion and that the use of RFID tags on completed panels will assist with sorting and crosschecking panels within the warehouse.
- RFID can draw panel identification information from BIM to factory production files that convert the architectural model to a panelised model of the building.
- For international or long distance shipping, geographic locating of freight can provide construction teams with notification of shipment.
- Using prefabricated panels will significantly reduce construction time and consequently costs, and that this can be accurately controlled using RFID to ensure the correct deliveries are being accepted on site.
- Usage of RFID tags and readers to verify correct sorting of panels in a given shipment for onsite storage and installation, thus reducing the time materials spend in storage onsite.
- Placement of RFID tags embedded inside or on timber panel does not significantly detract from performance of the RFID read through material (main construction materials are CLT and gyprock, and as such low levels of RFID interference are expected).
- RFID can be used in a Reverse Logistics System at the end of a building's lifecycle in order to ensure the correct material handling instructions are available to assist in disassembly and the sorting of products for reuse or recycling.

RFID Testing and research design

The authors aim to assess the following 7 aims by employing RFID in the construction supply chain on an active prefabricated timber construction project where the objective will be to:

1. Assess whether RFID can be used to measure time and resource utilisation, and track the fabrication stage of panels in factory (complements in place Enterprise Resource Planning systems (ERP)),
2. Assess whether RFID can be used at the factory to more efficiently stack the panels in order of construction site assembly in a shipping container,
3. Assess whether RFID can be used to automate the notification of construction teams that panel shipments are en route to site,
4. Assess whether RFID can be used by the construction team to access the location of shipping container, and obtain an accurate estimated time of arrival to the construction site,
5. Assess whether RFID be used by the construction team to verify that all panels are present and in the correct order in a shipment, as per the order, without physically unpacking or inspecting the container. This will be tested by linking panel RFID to a CAD/BIM model for assembly location (ie. panel B1-1 goes to this face of the building),

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6. Assess whether RFID can allow for basic data storage on a tag attached to a given panel concerning basic physical properties (engineering material characteristics, material composition, thermal properties, sustainability properties, SDS) or in a linked online database (to allow for safety and sustainability compliance verification),
7. Assess whether the placement of RFID tags embedded inside or on timber panels will detract from performance of the RFID reader once the panels has been covered by finishing materials such as plasterboard linings.

In order to measure time and resource utilisation, and track productivity in the fabrication stage of panel production in the factory, RFID tags will be fitted to prefabricated timber panels at the start of the manufacturing process in an area that will protect the RFID tag from damage during assembly. Information relating assembly design and material information and handling will be recorded on the RFID tag prior to being fitted on the panel. At the end of the manufacturing process the RFID tag will be read and the information related to manufacturing time and materials will be recorded to the tag and to the ERP system as well. Time comparisons between the traditional method of manual tracking and data entry will be compared with the automated RFID process. This approach is similar the approach identified by Loebbecke (2005) and Nagabhushana (2013) in the retail industry whereby RFID tags are attached at the point of manufacture and used to track items throughout the supply chain.

In order to assess if RFID can be used at the factory to more efficiently stack the panels in order of construction site assembly in a shipping container, the storage and handling team at the warehouse will use RFID readers to quickly and accurately verify panel identity prior to storage within the warehouse. In order to reduce unnecessary multiple handlings of materials in the warehouse and onsite like those identified by Razavi and Haas (2011), the panels can be stacked according to their shipping date, which will be quickly identifiable using the RFID reader. RFID tags can be used in quality control when loading panels into shipping container by scanning panels to review onsite installation order to ensure that the panels are loaded in the correct order. Thus creating a reduction in onsite material handling by the construction team because the panels come out of the container in the correct installation order.

In order to assess if RFID can be used to automate the notification of the construction team that a panel shipment is en route, an automated email will be generated when the shipping container is sealed and loaded for transport. The information related to shipping container contents, departure time, mode of transport, and estimated time of arrival, and a link to the GPS tracking will all be included in the email transmission.

In order to assess if RFID can be used by the construction team to access the location of shipping container and the estimated time of arrival to the

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construction site, the RFID tag on the shipping container will be augmented to allow for tracking using a standard GPS system. Just as was noted by Loebbecke (2005) when chronicling the retail industry, RFID tags will be electronically time stamped and then entered into the central computer of the goods tracking system which will allow both the panel manufacturer and contractor to track and locate the panels and shipping containers all along the logistic supply chain.

In order to assess if RFID can be used by the construction team to verify that all panels in the container are present as per the invoice and the panels are stacked in the order of building assembly, the construction team will use an RFID reader at the point of delivery to access the information related to the panels in the shipping container. Similar to logistics example noted by Nagabhushana (2013) the RFID reader will be used to determine the contents of the shipping container and each panel's individual identification and position within the container. The order of panels in the container will be checked against the construction plans using the cloud capabilities of the reader to view the CAD or BIM model.

In order to assess whether RFID can allow for the storage of panel physical properties (engineering material characteristics, material composition, thermal properties, sustainability properties, SDS) in the RFID Tag or in linked files in an online database (to allow for safety and sustainability compliance verification), the investigation will test two different approaches. The first approach will be to store the panel physical properties on the RFID tag itself to allow for quick access of the information via the RFID reader. The second approach will be store the panel physical properties in the CAD/BIM model and associate the properties with the RFID tag's identification number so that it can be accessed via the reader from the cloud after scanning the RFID tag. As was noted in Lee et al (2013) walking the construction site with an RFID reader in hand can be used to get precise information related to the panel's physical characteristics, the delivery times, and installation times. Furthermore, simulations will be done post construction to determine RFID can be used as Lee and Chan (2009) envisioned in Reverse Logistics Systems to assist in the identification of materials for recycling after the buildings useful lifecycle is complete.

In order to assess whether the placement of RFID tag embedded inside or on timber panel will detract from performance of the RFID reader once the panel has been covered by finishing materials like Cross Laminated Timber panels and gyprock, the researchers will test the readers and tags after the building has been occupied. This will allow for empirical testing to determine what impact different finish materials on the transmission of information from the tag to the reader.

In testing of RFID in the above mentioned ways, an RFID enabled prefabricated timber construction supply chain can be compared to a

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traditional prefabricated timber supply chain. Cost comparisons between the two paradigms can be compared and any potential cost benefits of RFID can be identified

CONCLUSION

Due to the thin profit margins experienced by firms in the construction industry, most firms are content to take a conservative approach when it comes to the implementation of new technologies. This conservatism has created the need for industry groups and academic to team up in order to test new technologies and identify any cost benefits to using technologies such as RFID in the construction supply chain.

The authors hypothesize that the implementation of RFID within the prefabricated timber supply chain will create cost savings in the form of a reduction in cost associated with the manufacture, storage, shipping and receiving, and on-site installation of prefabricated panels. The authors present a methodology for the empirical testing of RFID as a medium of information transfer and documentation, and intend to undertake tests that will examine the applicability of RFID with the prefabricated timber construction industry.

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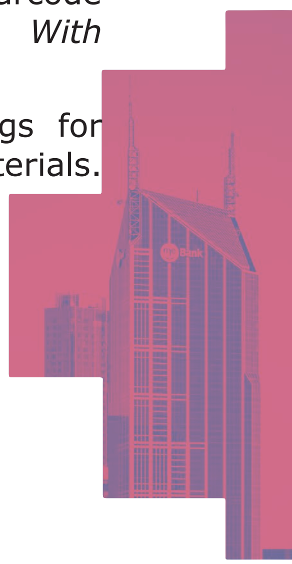

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PRELIMINARY INVESTIGATION OF THE RESIDENTIAL HOUSING CONTRACTORS' VIEW OF THE ADOPTION OF BIM TECHNOLOGY

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ABSTRACT

The construction industry increasingly embraces Building Information Models (BIM) in an attempt to enhance work practices and overcome difficulties inherent in complex construction projects. However, widespread use of BIM in small projects, specifically in the residential housing sector, is rarely evident. In an attempt to address BIM's lack of uptake amongst residential housing contractors, a study was initiated to better understand their information/technology needs and the site planning process requirements. The premise is that a construction-orientated BIM tailored to the specific needs of those residential housing contractors can offer better value and possibly contribute to the uptake of BIM technology in that sector. In the current phase of this study, pilot interviews were conducted with housing construction professionals in Victoria, Australia, to investigate some of the existing site and resource management procedures as well as the technology context. The paper reports on selected findings of these pilot interviews particularly the technology support and potential use of BIM in housing projects. The preliminary findings suggest that the technologies actually being used for construction management are quite simple with main focus on managing administrative functions such as procurement rather than undertaking a sophisticated onsite planning process. Furthermore, while the interviewees seem to be positive towards the adoption of new technologies such as BIM, they had concerns about the lack of understanding of BIM technology and the uncertainty about its impact on changing the existing work practices.

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Keywords: Building Information Model (BIM), Construction Management, Residential Housing, Resource Planning, Victoria.

INTRODUCTION

The recent proliferation of Building Information Models (BIM) technology is purported to address the complexity incorporated with the delivery of construction projects. The construction industry has increasingly adopted BIM in recent years in an effort to enhance work practices and redress the adversity in construction projects. However, the adoption is not widespread across all industry stakeholders (Ghaffarianhoseini et al., 2016). A good example is the relatively small contractors, e.g. those working in the residential housing sector, which did not necessarily follow suit (Georgy et al., 2016). Indeed, it is more likely for projects of higher dollar value to involve the use of BIM (Alabdulqader et al. 2013). The need for additional resources to adopt an advanced full-fledged BIM, for instance, has impeded the utilisation of BIM by smaller size contractors (Lui et al., 2015; Gerrard et al., 2010). Furthermore, while final outcome may be rewarding, the transition to more innovative BIM-centred process was not undemanding for the few small contactors that attempted to utilize such technology (Poirier et al., 2015).

The authors argue that a less architecture-focused and more construction-orientated BIM, i.e. one that better captures construction-related information, will offer more benefits to contractors including ones in the residential housing sector. Such construction-orientated BIM can help facilitate resource planning and the management of on-site operations. Hence, a study was initiated to better understand the residential housing contractors' information/technology needs and the site planning process requirements. An earlier stage of this research concerned a desktop research of the salient literature to understand the essence of on-site resource planning and type of information/knowledge required in housing construction. Outcome of the literature review was reported elsewhere (Georgy et al., 2016). Building on the first stage, the current on-going stage involves interviewing housing construction professionals in Victoria, Australia, to investigate some of the existing site and resource management procedures as well as the technology context. This paper reports on selected findings of the pilot interviews conducted to date, particularly the findings that concern the technology support and potential use of BIM in housing construction projects. A long term goal of the research, and subsequent to interviewing industry professionals, is to develop BIM testbed/s that can be used to examine the construction-orientated BIM concept.

The paper is structured as follows: first a review of relevant studies is presented followed by a brief description of the qualitative research methodology pursued. A summary of the research participants is then provided. Afterwards, the preliminary findings of the study are presented and discussed. Ties with relevant literature are established. Finally the paper ends with concluding remarks.

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BACKGROUND AND SELECTED LITERATURE

The Architecture, Engineering and Construction (AEC) industry constantly seeks for new methods to enhance quality, productivity, and efficiency, by eliminating waste and reducing construction costs (Alabdulqader et al., 2013). However, the intrinsic characteristics of the AEC industry, e.g. the diverse nature of required knowledge, the uniqueness of products and services, etc., inhibit the sector to compete with the other industries in taking on innovative technologies (Nicolini, 2002). Development of BIM as a revolutionary building design and construction technology is simply a response to this need by enabling the transformational changes throughout every phase of the project delivery lifecycle such as design, construction, and operation (Osan et al., 2012).

In fact, information and information-orientated technologies have been the centrepiece of many developments in the AEC industry in the past two decades. Sripraserit and Dawood (2002) evaluated the impact of adopting web-based information systems on the project stakeholders and suggested that the use of such systems enhances collaboration among project members by supporting communication, reforming the information flows in the supply chain and sharing information and documents. Peansupap and Walker (2005) supported this point of view and asserted that effective communication as a result of information technology utilisation enhances construction processes at different stages of the project. They argued that construction organisations increasingly perceive the potential benefits of information and communication technologies (ICT) and thus are more motivated to adopt and invest in these technologies. Furthermore, properly managed and integrated technologies such as BIM can provide a platform to support informed decisions in different business operations within the AEC projects (Aram et al., 2013).

Despite the opportunities a technology such as BIM offer to the construction industry, it can create a number of challenges for organisations wanting to adequately implement it across their mainstream practices. According to Aranda-Mena et al. (2009) these challenges are resulted due to the lack of globally agreed definition of BIM and understanding of its inherent attributes and characteristics. While BIM for some is an integrated technology to facilitate the design process and documentation, for others it is a new concept for managing projects by embedding new policies and principles amongst stakeholders (Aranda-Mena et al., 2009).

Peansupap and Walker (2006) also analysed the challenges in implementing ICT in construction organisations and suggested that efforts should be made at all personal, organisational and group levels to enable successful diffusion of a new technology. In the context of BIM, as a critical ICT, absence of appropriate contract structures supporting the BIM implementation, ambiguous risk allocation mechanism, unclear team

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responsibilities and interoperating issues between project participants are identified as major barriers to widespread use of BIM within the industry (Ghassemi and Becerik-Gerber, 2011). Another challenge reported by Suermann (2009) pertains to the need for a new set of skills and expertise in addition to the technical levels required for the conventional project setups. Subsequently, the effective deployment of BIM requires additional resources with specific essential skills and knowledge. Moreover, organisations need to make necessary adjustments in their organisational structure, strategies and process in order to earn the full benefits of a new technology (Weston, 2001).

Despite a wealth of literature regarding the benefits and challenges of BIM implementation, most of the BIM potential benefits are demonstrated on pilot projects; and practical experience to advance with BIM is lacking (Davies and Harty, 2012, Hooper and Ekholm, 2015).

RESEARCH METHOD

This phase of research employs a qualitative approach as advocated for the study of complex phenomena and when the objective of research is to develop new techniques and processes based on understanding and describing the phenomena from the participants' position (Flick, 2009; Creswell, 2013).

The choice of techniques for collecting data is highly influenced by the strategy adopted for conducting the research. For the "piloting" stage which the paper reports on, the data was collected through in-depth semi-structured interviews with four practitioners/experts who have been involved in residential housing projects and play significant –but different– roles in the project process. These experts were thus viewed to have the potential to provide high quality data with deep insight from different angles into the research problem being explored. Table 1 provides a summary of the interview participants at the pilot stage.

Interviews helped to document individual attitudes, feelings, beliefs, experiences and reactions. With semi-structured interviews, the authors were able to probe/ask detailed questions about the interviewees' views, and not adhere only to the interview guide. In addition, the semi-structured format allowed explaining and/or rephrasing the questions if interviewees were unclear about them.

Potential suitable residential builders were selected and invitational emails were sent directly to the participants or to the company's office seeking their availability and consent. Each interview took approximately 60 minutes. Interview was audio-recorded and then transcribed. This produced approximately 60 transcription pages in the text format. All interview texts were loaded to the latest version of qualitative data

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analysis toolkits, QSR, NVivo 10 to organise and assist with the analysis of content from these 4 interviews.

Table 1 Pilot Stage Interviews – Participants' Summary

Participant's Reference Number	Role/Position in Builder Organization	Role Responsibilities and Duties	Industry/Construction Experience
P1	Building Manager	Tracking jobs, coordinating site and trades supervisors client management, quality control and new products management	2 years as contract administrator, 6 years as site supervisor
P2	Business Operations Manager	Front end sales management, logistic coordination, project team management, building permits and administration	Over 15 years as the business operations manager
P3	Director	Business and construction management, purchasing and pricing management, suppliers management	9 years as construction and building manager, 17 years as the company founder and director
P4	Construction Manager	Managing engineering and construction jobs	5 years contractor administrator, 13 years construction manager

PRELIMINARY RESEARCH FINDINGS

Mixed attitude of the industry

Preliminary findings from the analysis of the pilot stage interviews indicate that residential builders have a mixed attitude towards the use of BIM or other new technologies in construction planning and management. While some are looking forward to seeing ways to embrace the new technologies as potential tools to add value to construction planning, others have concerns over the implementation of such technologies due to the uncertainty associated with the required changes to the status quo.

Commented on this, P3 stated that "we are always open to new ideas and always sit down with possible ways but what I'm passionate about the [team] always doing their role because I think you can only do your role as good as you are not as good as the computer is. So [about the use of BIM] I should say I would have to see it. I could not really make a comment until I physically sat down and looked at it and have seen how it would interact with each person".

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Concerns over transition and security of information

One of the main concerns on the use of BIM pertains to its impact on changing the current practice in transferring information from current tools and the risk of loss of some information during this information exchange. P4 contended "…transporting all the information from the current software that we have into the new one [is] always the hardest thing. I think that's the big thing especially for a company of our size where there is so much volume involved in there if all that information and all the codes need to be manually typed into this program. But more importantly, in building we have information for so long that we've got to guarantee our houses for years and we cannot afford losing any of them by using any new software".

Another builders' concern is the lack of comfort and confidence in the security of BIM with regard to the sensitive information it may capture and the accessibility of different stakeholders in the supply chain to such information. P2 emphasised that "…my first thoughts as a builder particularly on a larger scale, is that you want to make sure you're responsible for what you need to be responsible for. I just imagine a supplier or subcontractor tampering with our database and that just makes me nervous".

Need for simplicity and flexibility

Interestingly, the majority of the interviewed residential builders use a rather simple/basic set of software tools, mostly dependent on Microsoft Office products, for their construction management related activities. Moreover, the main focus of using these tools is to manage the administrative functions, e.g. procurement and vendor management, rather than undertaking a sophisticated onsite planning process. Yet, it is to be noted that the software they use is likely suited to the way they build and how they customised their products.

P1 states that "…the software we are using is an application on Microsoft Excel. If you were doing a lot standard design homes then a program like that would be great because it's repetitive. I think our current software is great when things are repetitive. I think sometimes when you have things that are changing for every job; the software [we are using] can be maybe making things harder than it needs to be".

Although the builders indicate that they are satisfied with the current software in use, they acknowledge the need for more integrated toolkit, such as BIM, to incorporate various activities throughout the project lifecycle. However, they show reluctance to adopt advanced software due to what they perceive as the rigidity and inflexibility of these tools.

P2 asserted that "If [the software] is too structured it can nearly be its downfall so I believe it should be a bit looser and you can play with it a

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bit. That's probably the one benefit that we have with our [basic] program is that there's some really good structure to it but it's not all regimented that you have to do it and then if you don't do it, it allows us to play a little bit".

Required extra cost and efforts

Finally the extra cost, resources and skill sets required for the use of a new technology, i.e. BIM platform, are other barriers to utilising the inscribed capabilities of BIM within builders. Particularly, since BIM is realised as a new technology with no or little real life evidence of additional benefits or value to companies in the residential housing domain, the industry is yet to be confident to culturally and financially invests on its widely implementation.

P4 emphasised this issue and indicated that "…my genuine opinion about benefits of the BIM, in a nutshell, is that there is a need to keep it real so when you keep it real you're working like real situations and you can make decisions based on real information and not things that might happen it's more about what is happening".

DISCUSSION AND PARALLELS TO PAST RESEARCH

Several researchers have developed specific BIM-centred approaches for improving site planning and construction management. For example, Moon et al. (2013) developed a BIM-based construction scheduling method; Choi et al. (2014) demonstrated the use of BIM in construction work-space planning, while Zhang et al. (2015) proposed to leverage BIM data for job hazard analysis on construction sites. Due to BIM being "expensive to operate and maintain" (Alabdulqader et al., 2013), it cannot be expected that smaller size contractors widely embrace this technology. Interviewees have indicated that the use of technology in their respective organisations is limited to simple tools, e.g. Microsoft Products, which they can tailor and customise to their needs and specific building practices. However they also perceive that further benefits might be attained if other more advanced technologies e.g. BIM are properly used. This view coincides with the general conclusion of the study by Peansupap and Walker (2005) regarding the adoption of new technologies in construction organisations.

It is argued that the benefits of BIM are abundant (Gerrard et al., 2015). Through literature review and case study research, Barlish and Sullivan (2012) identified benefits such as duration improvement, reduction in engineering and construction costs, etc. In their work, Barlish and Sullivan (2012) compared two groups of construction organisations, with one group adopting BIM approaches while the other adopting non-BIM approaches and showed that BIM adoption made a difference in the tracked performance metrics. Interviewees of the herein study raised a

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relevant point that some real life evidence in the residential housing sector should be demonstrated before they attempt it in construction and resource planning. Comparable research in the housing sector to that of Barlish and Sullivan (2012) can contribute to such goal.

Indeed, there are barriers to adopting advanced BIM technology within small construction organisations. Interviewees cited, for instance, the skill sets needed to embrace such an advanced technology. Apparently, acquiring the right skill sets will mean additional resources which they are reluctant to pay for without prior evidence of downstream return on investment (ROI). Hosseini et al. (2016) and Rodgers et al. (2016) examined construction SMEs in Australia and confirmed that a lack of knowledge within these SMEs and across the entire construction supply chain is not the actual barrier to BIM uptake but rather the risks associated with an uncertain return on investment (ROI) for BIM as perceived by the key players in these SMEs. In addition to the aforementioned, the herein study revealed the interviewed practitioners' general awareness of some of the IT-related challenges of migrating to BIM-orientated approaches, including system compatibility, data transfer and exchange, security and access authorisation, application adaptability and customisability, and others. Yaakob et al. (2016) informed that the success of BIM uptake depends on a variety of critical success factors (CSF) including ones that relate to technology e.g. interoperability, safety/security, and user interface.

By the end, one cannot say that the interviewees were against the adoption of BIM technology for site planning and construction management in housing construction projects. However they did not seem to be ready to be first adopters. They preferred to have a proven record that they can follow since this move will entail investment in resources and equipment.

CONCLUDING REMARKS

This paper has reported on the preliminary findings of the pilot stage of a study, which aims at investigating the existing site and resource management procedures as well as the technology context within selected residential housing builders in Victoria, Australia. As discussed, the literature has informed that the level of BIM uptake is not necessarily the same across the entire spectrum of the construction industry and that smaller size contractors/builders are less likely to be among the typical adopters. Therefore, it was critical to understand the builders' attitude and perceptions towards the implementation of BIM as a construction planning and management tool.

The preliminary findings suggest that the interviewees use simple software tools for the purpose of construction planning. These tools do

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not necessarily cover the more sophisticated functions of construction management e.g. safety analysis, site layout planning, crew planning and work sequencing, and so forth. Despite this and the potential of BIM, interviewees had their concerns e.g. a possible incompatibility between the software currently in use and the BIM platform might lead to a loss of invaluable information, the possible insecurity of sensitive information and the risk of access by unauthorised individuals/stakeholders, and others. But on the other hand, the interviewees still recognised the potential value added to construction planning when using new technologies such as BIM, despite still being reluctant to culturally and financially invest on BIM implementation within their organisations. This is primarily the case due to what they perceive as a lack of documented evidence to justify its cost-benefit in the housing sector.

One has to keep in mind that the findings reported in this paper represent a very small sample and is only intended as part of the pilot study in the interviewing stage. In other words, the sample cannot be considered adequate to represent the entire residential housing construction sector in Victoria, Australia. The full-on study where more industry practitioners will be interviewed may reinforce or alter some or many of the reported findings. Nonetheless, through analysing the interview content, several parallels have been identified with the more generic literature on BIM technology and its adoption in the construction industry. This included various studies addressing the enables, barriers and concerns of industry practitioners to BIM use in big as well as small organisations.

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Understanding the benefits of constructing a residential house with a heart of cold-formed steel

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ABSTRACT

Constructing residential houses with cold-formed steel in Australia dates back to the 1940's when there was a shortage of timber for use in the industry. This subsequently led to the formation of the National Association of Steel-Framed Housing (NASH) in 1982 with the objective of promoting the use of cold-formed steel in the construction industry, in particular for application to construction of low-rise residential houses. Over the last few decades, NASH has made significant progress in promoting steel and has led to the inclusion of steel-framed housing in the Building Code of Australia (BCA) and the development of a standard on residential and low-rise steel framing. Conventional detached housing is the largest single form of residential construction in Australia with approximately 120,000 built in 2015. Therefore, the safety, durability, performance and long-term low operational costs over the 50-year design life of a typical residential house are of significance. Constructed residential houses satisfying these requirements would not only translate to significant savings to homeowners personally but also to the nation. This paper discusses the benefits of using cold-formed steel for constructing low-rise residential structures. Based on a full-scale experimental study that was undertaken to assess the overall performance of a brick veneer steel-framed structure, the performance-based requirements of residential houses built of cold-formed steel framing are evaluated and discussed.

Keywords: Cold-formed, Low-rise, Residential structures, Steel framing.

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INTRODUCTION

In Australia and New Zealand, the most common form of residential construction is "brick veneer" single or double storey houses, generally referred to as "light framed construction". These domestic houses and construction form are also warmly embraced in the United States and

Canada. Brick veneer form of construction consists of a wall system that has a flexible structural frame (timber or steel) that supports an external skin of brick wall. The wall serves the purpose of cladding only and offering no form of structural support. Brick ties serves as the connecting component in the wall system tying the external skin of brick wall and the load bearing structural frame. When the structure is subjected to any form of imposed loads, it is expected that the brick wall transfer these loads to the load-bearing frame via the brick ties. Internally, the structural frame is often complete with plasterboard lining which forms an aesthetic pleasing internal finish to the walls.

Traditionally, timber has been the most common structural frame used for the construction of light framed houses in Australia. It was not until the 1940's when the Australian building industry experienced significant shortage of timber (Hancock and Murray, 1996; NASH, 2009a) that the use of cold-formed steel framing systems was introduced for the construction of domestic houses and has since proved as a viable alternative. While the use of cold-formed steel framing for light framed construction in Australia has been successful in terms of performance, at its inception stages, its introduction into the building construction industry faced some difficulties. Cold-formed steel had no standard design available at the time and was not part of the Building Code of Australia. This initially inhibits recognition of the products by building practitioners. These challenges were alleviated by the formation of the National Association of Steel House Framing (NASH) in 1982, with the objective to promote the use of cold-formed steel for residential houses and further support growth, develop educational and training programs for industry practitioners. To date, NASH have developed numerous design guides including a handbook for the Design of Residential and Low-rise Steel Framing (NASH, 2009). NASH have also satisfactorily provided testing and documentation on the performance requirements for cold-formed steel framing that have led to its inclusion in the Building Code of Australia (ABCB, 2006). Whence, the innovative use of steel framing has evolved over the years, continually used for construction of residential houses in Australia and have become popular with industry practitioners.

COLD-FORMED STEEL FRAMING

Cold-formed steel framing sections used for framing components in residential houses in Australia are fabricated from steel that complies with AS 1397, 2001. The components are typically from steel designated as G550 galvanised steel sections (AS1397, 2001). The G gives an indication of the mechanical properties while the 550 represents the yield stress of the steel in Megapascals (MPa). The high strength and ductility of cold-formed steel frames complemented with their robust riveted connections makes them ideal for the construction of domestic houses in areas of high wind speed like Queensland. Such houses are also expected to perform

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extremely well when constructed in seismic regions like New Zealand (Bruneau et al., 2010; Clifton et al., 2011; Paton-Cole et al., 2012; Paton-Cole, 2014). Cold-formed steel frames offer many advantages such as dimensionally stable, high strength and stiffness, lightweight, easy prefabrication, mass production, easy erection and installation and 100% recyclable. In addition, they are termite resistance, non-combustible and generally easy to transport. The galvanisation of cold-formed steel sections (AS1397, 2001) protect the material against corrosion, which means they can last for many decades and reducing long term maintenance costs. As cold-formed steel frames are often prefabricated assemblies, they offer uniform quality with shorter construction times and reduced wastage. In a recent study conducted to evaluate the potential of waste reduction through offsite construction (WRAP, 2008), it was concluded that the offsite production of cold-formed steel frames is an exemplar to highlight waste minimisation.

Cold-formed steel application goes beyond residential construction and commonly used for internal partitions and infill panels for commercial, educational and industrial buildings. In Australia, cold-formed steel is increasingly being used for multi-storey apartment buildings and has popularly been used for medium rise residential buildings in the United States. The numerous advantages offered by cold-formed steel have resulted in extensive application in both commercial and residential projects in the United States, with hundreds of thousands of residential houses built over the last two decades (SFA, 2007). For residential constructions in the UK, cold-formed steel framing techniques are often used for single occupancy dwellings, medium rise and multi-occupancy buildings (WRAP, 2008). Conventional detached housing is the largest single form of residential construction in Australia with approximately 120,000 built in 2015 as reported by the Australian Bureau of Statistics. A significant percentage of these houses were built using cold-formed steel structural framing in a typical brick veneer construction form as shown in Figure 1 for a detached house.

(a) (b)

Figure 1: (a) Residential house framing with cold-formed steel; (b) Brick veneer house built with cold-formed steel

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To better understand the behaviour and evaluate the performance of cold-formed steel frames, numerous studies has been undertaken to evaluate and establish the structural adequacy and performance of full scale houses built with cold-formed steel (Barton, 1997; Gad, 1997; Paton-Cole et al., 2011; Paton-Cole, 2014). All these studies reported exceptional performance of the tested cold-formed steel elements, with all test results surpassing stipulated code requirements. Other studies have also been conducted to investigate the behaviour of these structures under fire conditions (Pantham and Clifton, 2014) with an exceptional performance reported.

In the past, cold-formed steel was not competitive with traditional timber framing due to the basis of cost, manufacturing capability and trades acceptance. However, due to recent industrialised innovation in cold-formed steel production like the FRAMECAD "factory in a can" manufacturing technology (FRAMECAD, 2009), the use of cold-formed steel in residential construction has gained increased popularity in Australia and New Zealand while being cost-competitive to traditional framing methods. With recent advances in manufacturing techniques, cold-formed steel manufacturers are continually improving a variety of sections and connections in order to produce more cost competitive products. NASH further provides educational and training programs for industry practitioners as well as developing and maintaining design standards for cold-formed steel. These developments have enhanced the confidence of industry practitioners to employ the use of cold-formed steel in a variety of applications. The recent inclusion of the NASH standard in the National Construction Code (ABCB, 2006) has made it easier to specify and design residential houses using cold-formed steel. The deemed to satisfy requirements detailed in the standard streamlines the design, detailing and construction processes.

Understanding the advantages and benefits cold-formed steel framing has to offer, there is the potential to construct exceptionally safe and efficient residential houses. Significant failure and likely collapse of structures in particular during natural disasters or fire is not only life threatening, the economic losses and disruption to amenities can be great. Therefore, the safety of residential houses is not just important at a personal level but of benefit to the community and a nation as a whole. With the thousands of residential houses built across Australia every year, the economic savings from using cold-formed steel framing would be enormous with better-expected performance of such houses once in service.

House framing components

Residential houses built of cold-formed steel consists of three major components namely floor framing, wall framing and roof framing units as described in the following sections. The concept of using cold-formed steel for residential house construction is to use light, high strength steel

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sections to construct the load bearing structural frame in a configuration similar to traditional timber construction. The various framing components can be constructed by either stick framing or prefabricated panelised units. Factory precision prefabricated approach is most popularly adopted, as the finished components are straight and accurate, light and easy to transport and guarantees a faster and easier installation.

Floor framing

Similar to traditional framing methods, two typical floor systems are used in constructing residential houses framed with cold-formed steel. The first of these is the "concrete slab on ground system" such as a stiffened or waffle raft footing and the second is the "suspended floor system" which constitutes a floor and subfloor system. Various proprietary systems are available for the suspended floor option and incorporates easily adjustable levelling mechanisms that makes them very easy to install and saves time. NASH general guide (NASH, 2009a) and Handbook (NASH, 2009) provides comprehensive details of the various systems including hold down connection details.

Wall framing

Walls framed with cold-formed steel members in residential construction consist of components such as studs, noggings, top and bottom plates and wall bracings. The walls are designed as either load bearing or non-load bearing walls. A variety of stud sections are available for selection with different geometric properties and load capacities. Walls that are braced with either strap or sheet bracing resist lateral loads. External walls of cold-formed steel framed houses can be cladded with a variety of materials, though brick cladding is more popularly used in Australia due to its aesthetic appealing virtue. Internally, the wall frames are usually finished with plasterboard lining. NASH Handbook (NASH, 2009) provides comprehensive details of the available framing options and connection details that can be used for construction.

Roof framing

The roof structure of a residential house framed with cold-formed steel sections generally consist of roof trusses that are fabricated in different shapes and sizes. The roof cladding can either be of steel sheeting or roof tiles and the nature of the roof structure is significantly influenced by the type of roof cladding used. Roof battens that are laid over the roof trusses generally support the roof cladding. The roof structure is generally braced to ensure the roof resist imposed loads as a single unit. Internally, the ceiling-framing members once lined with traditional plasterboard provides a diaphragm action that enhances the stability of the entire roof structure.

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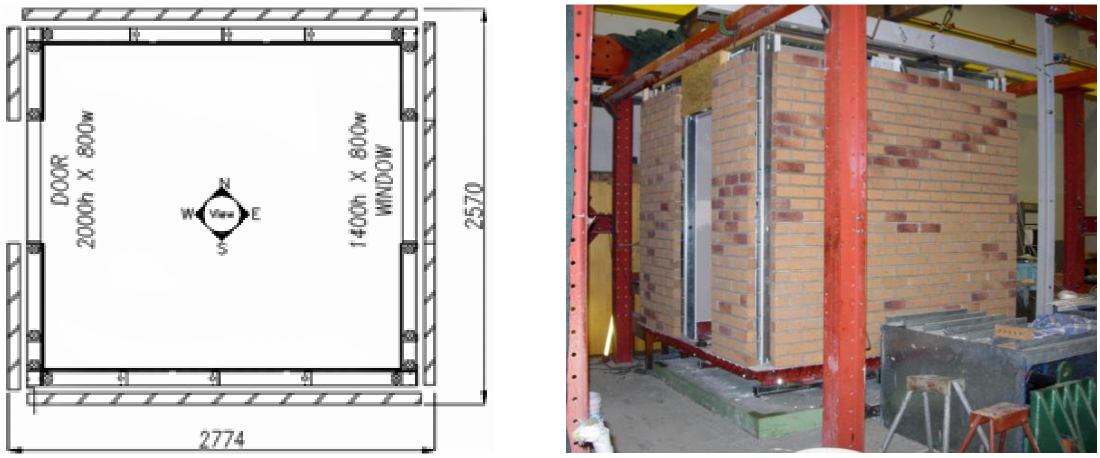
EXPERIMENTAL TESTING

To assess the overall performance of a structure built out of cold-formed steel, a Test House was designed for a comprehensive shaking table test program. A shaking table is used to simulate artificial earthquake and a test of this nature would represents one of the worst conditions to which a structure would be subjected to during its service life. As shown in Figure 2, the Test House was a full-scale single-room structure replicating typical construction practice of a steel-framed brick veneer house as built in New Zealand. It measured approximately 2.6m x 2.8m x 2.4m high. The Test House comprised of steel frame walls and ceiling with brick veneer cladding and plasterboard lining, fully constructed using typical full-scale components. The framing and bracing members were made of 0.75mm G550 Z275 galvanised steel sections (AS1397, 2001). All the framing connections between plates, studs, noggings and bracing were screwed connections in compliance with the NASH Handbook (NASH, 2009).



(a) Plan of Test House (b) Completed Test specimen

Figure 2: Geometry of Test specimen

The brick veneer walls were constructed using standard New Zealand 70 series clay brick units measuring 230mm x 70 mm x 76 mm high with standard five core holes. The bricks were bedded with 10mm thick mortar joints with a standard mix of 1:0.5:4.5. Type B Eagle brick ties were used for connecting the veneer walls to the light steel framing. Polystyrene thermal break strips 40mm wide x 10 mm thick were glued to the external flange of each stud through which the tie screws were drilled. A concrete roof slab weighing 1500kg was used on top of the Test House to simulate the equivalent mass from a house roof. Walls and ceiling were lined with 10mm thick plasterboard and secured with screws.

To assess the performance of the Test House against specific design performance criteria, a design earthquake was selected as input excitation to the shaking table. The selected excitation was the 1940 El-Centro (ELC) earthquake that is compliant with the New Zealand Earthquake

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Loading Standard (NZS1170.5, 2004). The specific levels of excitation that were targeted are listed in Table 1. To evaluate the Test House performance, displacements and accelerations were measured at numerous locations on the Test House using Linear Voltage Displacement Transducers (LVDTs) and uniaxial accelerometers respectively. Webcams were installed at strategic locations to monitor the relative movement between the structural frame and veneer through the cavity.

Table 1: Earthquake levels adopted for testing and corresponding performance criteria

Earthquake design level	Scale relative to El-Centro	Required performance limits
Serviceability Limit State (SLS)	0.89 El-Centro	Localised hairline cracking of veneer and lining at most vulnerable locations. No post-earthquake remedial work required.
Ultimate Limit State (ULS)	1.28 El-Centro	Noticeable cracking of veneer and linings, brick loss limited to < 5% of bricks or the top two rows above the top row of ties. Visible damage to frame expected but not to be significant and not to reduce ability of frame to support house.
Maximum Considered Earthquake (MCE)	1.72 El-Centro	Significant linings and framing damage but no collapse of framing. Significant brick loss.

Experimental results

The Test House was subjected to progressively increasing ground excitation along the two principal axes of the house considered as North-South and East West directions as shown in Figure 2. A summary of the testing sequence and observations made after each test are presented in Table 2. The Test House performed very well in both directions of shaking up to MCE level earthquake as described in Table 2. The Test House performance is considered to be exceptionally good at this intensity of shaking in comparison to the performance criteria outlined in Table 1. With no evidence of significant damage on the Test House after applying MCE in each direction, the selected input excitation was further scaled increasingly to impose more severe shaking. Up to 2.6 times ELC no bricks were lost or any significant damage occurred in the North and South brick veneer walls. This is extremely good performance given the fact that the Test House had already been subjected to 7 high level earthquakes prior to 2.6 times ELC. It is considered impossible for a single house to experience this number and severity of earthquakes during its design life. At the end of 2.6 times ELC, a partial failure of the connection between the top diagonal bracings and top plates on both East and West walls was noticed but no bricks loss or tie pullout observed.

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Table 2: Summary of tests performed and observations made

Test No	Earthquake level and direction		Observations
	North-South	**East-West**	
1	SLS		No damage observable whatsoever.
2	ULS		Minimal hairline cracks in the plasterboard lining at window top corners. Very limited hairline cracks at locations in brick veneer adjacent to opening. No damage to any brick ties, the screws or the thermal break.
3		SLS	No increase in damage from test 2.
4	MCE		Minor increase in cracking of internal plasterboard at window corners. No increase in cracking in brick veneer. No visible damage to any ties.
5		MCE	No increase in damage from test 4.
6	1.16MCE (2.0 El-Centro)		Noticeable rocking of wall brick piers at base of window. Hairline cracks post test extending right across pier base. No bricks lost. No visible damage to any ties. No visible damage to steel framing. Plasterboard cracks in window top corners now remaining open approximately 1mm after test.
7	1.34MCE (2.3 El-Centro)		Increased rocking and cracking during test. No new cracks. No bricks lost. No visible damage to brick ties but in plane twisting for the East and West walls. No evidence of pullout of any ties. No visible damage to steel frame.
8	1.51MCE (2.6El-Centro)		Partial failure of connection between the top of diagonal brace and top plate for East and West walls. No bricks lost. No tie pullout from frame or veneer.
9	1.57MCE (2.7El-Centro)		Failure of connection of diagonal brace to top plate in East and West walls. Top 2 rows of bricks lost in East and West walls. No bricks lost from the North and South walls. Minimal to no damage to ties in the North and South walls. No tie pullout from studs in any location.

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At the end of the test at 2.7 times ELC, a complete connection failure occurred at the ends of the top diagonal bracing in both East and West walls. Despite the very large displacement of the frame, the brick ties did not separate from the studs or the veneer in the North and South walls. This reflects a high degree of resistance and robustness of the connections of the ties at both the stud end as well as the veneer end.

Based on visual observations, the connectivity between the veneer walls and the frame were maintained throughout the test with no ties disengaging except at the maximum level of shaking at 2.7 times El-Centro when the top two courses of bricks on the East and West walls fell off. This was due to failure at the connections of the diagonal bracing and excessive twisting of the ties on the East and West walls.

CONCLUSIONS

Light framed domestic structures are predominantly used for residential purposes in many countries including Australia and New Zealand. The use of cold-formed steel framing for constructing these houses has gained significant attention by industry practitioners due to the numerous advantages steel has to offer. As cold-formed steel have become quite cost competitive in recent times, it can provide the economic platform for constructing low maintenance residential houses with better-expected performance. Tradesmen that are familiar with timber framing methods can adapt fairly easily to cold-formed steel material and NASH provides the required education and training programs for industry practitioners.

A Test House constructed of high-strength cold-formed steel frame with brick veneer cladding and plasterboard lining was tested under earthquake loads to assess the performance of a typical structure when subjected to extreme loading conditions. Given that the Test House was designed using conventional methods, constructed from typical components and built using standard techniques it would be considered to be representative of brick-veneer light steel framed construction. With its excellent performance under an extremely onerous earthquake testing program, it can be concluded that such a form of construction would be expected to perform very well in high wind and seismic areas. Based on the test results presented in this paper, it can be concluded that houses built with cold-formed steel framing would perform exceptionally well in disaster prone areas in Australia, where a robust structure of this nature is required. Hence, with the advantages and benefits cold-formed steel framing has to offer, there is the potential to construct exceptionally safe and efficient residential houses.

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GLOBAL MOBILITY EXPERIENCE OF OUTBOUND CONSTRUCTION MANAGEMENT STUDENTS: THE CASE OF WESTERN SYDNEY UNIVERSITY

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ABSTRACT

This study focuses on enhancement of job opportunities in international and national markets for construction management students by providing global construction industry experience (IE) placement. There is an increasing trend towards globalisation in the construction industry. This sort of construction training in the international context also improves student's learning experience and global connections. The Australian Government's New Colombo Plan scholarship provides funding for work and study experience for Australian students travelling to the Indo-Pacific region to further their education. All Australian universities welcome significant numbers of inbound international students as well as increasingly encouraging outbound student mobility. This paper reports on the experiences of a number of outbound students who are involved in studying construction management. Through case study research, it was found that international work placements broadened the knowledge of students highlighting similarities and differences when working in an overseas country. Students made useful contacts and were able to improve their employability in both the local and international construction management sector. Their industrial placement was facilitated by the Australian Institute of Building and Hong Kong Institute of Project Managers through professional networks. This study also recommends that this sort of industrial placement and student exchange programs can enhance their communication skills and understanding of the global construction industry practices.

Keywords: Australian education, Construction industry, Global mobility, Industrial experience, Outbound students.

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INTRODUCTION

Many students obtain an exciting opportunity to undertake part of their studies overseas and to develop skills in communication, analytical ability, and problem solving while enhancing motivation, independence and confidence (Hardie and Saha 2016). Global mobility of outbound students may involve internships, semester exchanges, study tours and work placement shadowing (AIM Overseas, 2017). Global mobility team provides advisory, compliance and administrative services, along with outstanding technology, to make this seamless for overseas study. Global mobility makes the movement of employees as streamlined and cost effective as possible, both domestically and globally.

Over the past decade, there is an increasing trend towards globalisation in the construction industry (Hardie and Saha 2016). Industry experience (IE) placement has performed a valuable role in enhancing discipline-related skill sets, improving confidence and making student more employable (Pirie and McNicholoas, 2015). Industrial training imposes a significant influence on student's professional development and employability (Mendez, 2008). Researchers and scholars investigated this field of study in various aspects such as the effectiveness of internship (Beard, 2007), its relationship with employability (Knouse et al., 1999), the framework of the internship program (Narayanan et al., 2010) and its impact on the performance of the students (Hardie and Saha, 2016). However, there is limited study on global mobility for Australian students in the construction management fields abroad.

Research both in Australia and internationally shows that the benefits of international mobility are far reaching and they reward the individual, future employers, and industry as well as sending and receiving training providers (AIM Overseas, 2017). Global mobility is still a relatively new phenomenon in vocational/professional education and training in Australia (Hardie and Saha 2016). Despite the global movement of students growing significantly over the past decade, Australian students engaged in vocational education and training have not been afforded many international exchange and placement opportunities (AIM Overseas, 2017). However, the mobility of employees has increased by 25% over the past decade with further growth up to 50% expected by 2020 (Price Waterhouse Coopers, 2017). The benefits of outbound mobility for Australian training providers (AIM Overseas, 2017) can be summarised as:

1) enhanced bilateral and multilateral networks and partnerships,

2) enhanced institutional positioning and increased demand for programs,

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3) increased organisational awareness of international activities and opportunities,

4) access to professional development for educational staff,

5) globally aware graduates trained with up to date international trends and practices, and

6) a well-rounded professional and sustainable internationalised education program.

In order to achieve these benefits, the Australian government established the “New Colombo Plan” in 2014 creating a source of funding to provide opportunities for Australian undergraduates to study and undertake work placements in the Indo-Pacific region. This program offers funding for scholarships for overseas study, mobility grants for short-term study, internships, mentorships, practicums and research initiatives. This sort of training in the international context will lift Australia’s profile in the region and can become a driving force for future prosperity (Hardie and Saha, 2016). The Australian Government has committed more than AU$150 million between 2015-2016 and 2018-2019 periods for this scheme (New Colombo Plan, 2016). The schemes funding allocations for each year is reported in Figure 1.

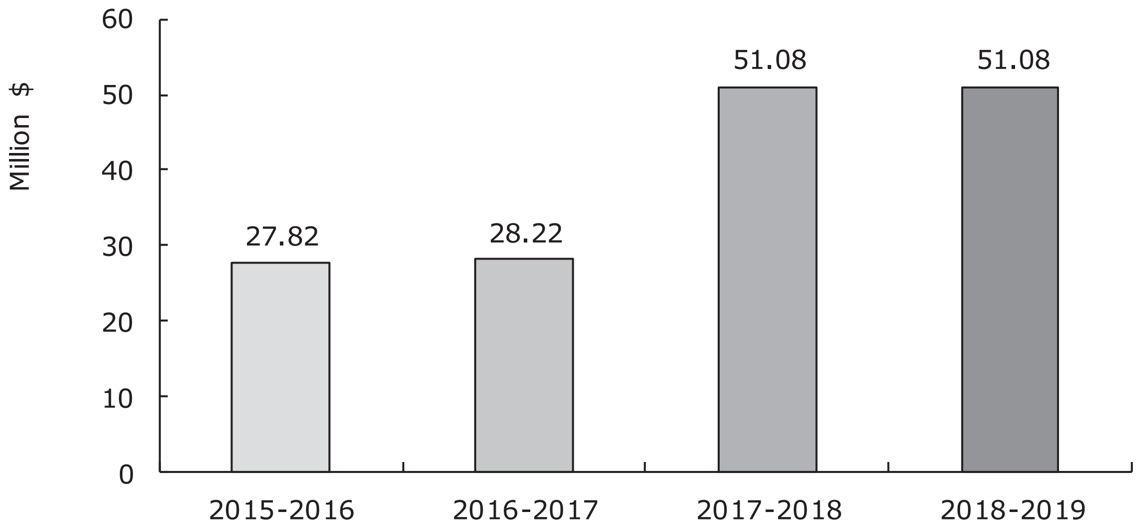

Figure 1. Mobility program funding for New Colombo Plan 2015-2016 to 2018-2019

The purpose of this study is to explore the benefits of the Colombo Plan scholarship for Western Sydney University students located in Hong Kong for industry experience in construction management. The main objectives of this study are to:

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1) assess the improved employability of students in the local and international construction sector,

2) reveal enhanced networking and communication skill developments, and

3) highlight the new knowledge gained by students in a professional environment.

RESEARCH METHODOLOGY

The research method chosen for this paper is a single case study design, which is made up of individual observations and data collected in interviews. Case study methodology as described by Yin (2014) is a suitable research methodology to address the "how" and "why" research questions especially when the study focus is contemporary rather than historical (Hardie and Saha 2016). The case study on construction work experience in Hong Kong in 2015-2016 was conducted within the discipline of Construction Management (CM) at Western Sydney University (WSU). The case study data consists of reports submitted by the students immediately followed by an interview after their return from the placement and employer comments submitted at the end of the placement. This process involved unstructured interviews focusing on the impact of the work placement on their careers as well as student self-reflection. This case study research was subjected to Western Sydney University ethics approval.

Host industrial partners were also surveyed online so as to receive feedback on students' performance and explore the viability of future support of this mobility program.

BACKGROUND OF THE WSU GLOBAL MOBILITY PROGRAM

Western Sydney University (WSU) has a strategic mission that offers an innovative and accessible range of student mobility programs with international partners to support their development as global citizens. The CM discipline at WSU has a teaching philosophy of blending industrial experience with academic learning, encouraging students to engage with global mobility programs through internships. The University strongly supports the CM group in enhancing outbound student mobility through international industry placement for improved employability of students in the local and international construction sector. This mobility program also aims to improve retention rate of high quality students in the CM programs at the Western Sydney University. Academic staff and WSU Careers Advisors were involved in recruiting students undertaking CM courses at WSU to participate in a five-week internship in Hong Kong, during 2015-2016 summer break.

Prior to 2015, there had not been any systematic targeting of students within the construction management degree at Western Sydney University for outbound placements. Any overseas placements relied upon the motivation of individual students and staff on an ad hoc basis. Under the Global Canopy project led by RMIT University a more intensive targeted approach to global mobility (McLaughlin et al., 2017) was adopted. Western Sydney University team members comprising a student and a staff member visited Hong Kong in 2015 and subsequently attended a meeting with prospective candidates at the Global Showcase event held at RMIT University, Melbourne, in April 2016. WSU participants shared their relevant experiences gained during their visit in Hong Kong with both inbound and outbound students at the RMIT showcase.

Recognising that opportunities in construction management within Asia was a key element of the project, staff promoted the concept of on the job training and work experience internships as a component of the mobility project. This was attractive to students as the project provided five weeks of industry experience which was recognised as part of the mandatory industry based learning subject of their degree.

Selection Process

In 2015, all CM students from within the undergraduate degree program were invited to submit expression of interest for the international mobility program as part of the Colombo Plan scholarship. Ten scholarship awards were available. The program consisted of internships aimed at leading construction companies in Hong Kong. Construction management students were required to observe how technology, logistics, contractual obligations and economics interact on large scale building projects. To ameliorate some of the challenges with mobility successful candidates were interned in pairs within one of the participating organisations. Applicants seeking the Colombo Plan scholarship were required to write at least one to two paragraphs outlining the achievement in the following aspects:

1) work experiences with actual examples;

2) academic performance; and

3) community activities.

Students were also required to satisfy the following specific criteria of the internship program:

- Completion of a ‘General construction induction’ program (white card).
- Strong interest in project management and the effective delivery of building projects.

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- General understanding of office procedures and quality control methods.
- Be flexible and self-motivated.
- Be able to work in a team environment as well as working independently.
- Be able to work in a cross cultural setting and adjust to living in a different country.
- Provide one academic referee and one personal referee.

Some features and assistance of the internship included:

- An internship with a leading construction company and University in Hong Kong.
- Some financial support (up to $2000 was provided by DFAT for each participating student).
- Pre-departure information sessions including a cross-cultural seminar.
- 24/7 support from WSU Careers Unit.
- Assistance with airfare and transportation
- Assistance with accommodation.
- Assistance with Visa processing.
- Travel insurance.

Twenty student applications were received for the ten scholarship awards available and all applicants were interviewed. Interview questions for the selection process were designed to ascertain student's motivation towards the global mobility program and their understanding of the multicultural environment of the host country. Interview questions explored student's understanding of work experience and the hosting organisations. Through the interview process they were also assessed as to how well they communicate.

The Placement

The two Directors of Academic Programs (DAPs) for the CM discipline and WSU Career Unit arranged for the successful students to work at one of the following leading construction companies in Hong Kong during January 4 to February 5, 2016:

Table 1: List of Host Company in Hong Kong for the industrial placement

Host Company	Area of Expertise	Student no.
Company A	Quantity Surveying	2
Company B	Civil engineering, building, foundations construction, electrical & mechanical installation, and fitting out works	2
Company C	Construction, maintenance, renovation, design and build of building projects	2
Company D	Construction, maintenance, renovation, design and build of building projects	2
Company E	BIM Research Lab, Industrial services covering Building Information Modelling (BIM), process simulation solutions, and professional training to the construction	2

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RESULTS AND DISCUSSION

Outbound students worked on range of projects and functions including civil construction, contract administration, and Building Information Modelling (BIM). Each of the students had to sign an employment contract with their placement company. The employment contract outlined working hours, remuneration, code of conduct, responsibilities and their supervisor's details. A staff member from WSU also accompanied these students for one week to mentor them on the importance of this internship program and to monitor their progress. The staff member also had an opportunity to visit a number of construction sites and university facilities so as to collect information on modern construction facilities available within the university sector and construction industry in Hong Kong.

Student Experience: Construction Virtual Prototype Laboratory

Facilities at a Construction Virtual Prototype Laboratory (CVPL) (Company E) provided students with training on BIM software applied to a real-life project. Technical and tutorial assistance was provided to students by technical officers. Students were also provided with daily tutorial activities with technicians and academics who monitored their progress. This training included an opportunity to visit the respective live construction sites and compare their computer models against progress on construction projects. Students provided feedback on the training on BIM and noted in their reflective journals that WSU had no such facilities at the moment and they acquired invaluable training on emerging topics such as BIM. These skills can assist them finding a job in the local and international market. The CM discipline at WSU is already considering implementation of BIM education in the current CM courses which lacks high level object oriented modelling for construction technology courses.

Student Experience: Pre-cast Construction Fabrication Site

Figure 2. Company D site in Hong Kong for Precast construction

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Students also worked on another BIM project (Company D) consisting of 7200 units across 9 blocks. All walls and ceilings were erected using pre-cast blocks with a batching plant on site. Figure 2 shows the photo of the precast construction components produced by Company D in Hong Kong. Students were excited about the use of modern construction methods and project management tools and provided positive feedback towards this internship program.

Student Report and Interview

As part of the condition of the scholarship all students submitted a reflective report at the conclusion of the placement. Students noted in their reflective reports and during the unstructured interview, how great the industry experience was. Some of the findings listed from the reflective diaries and interview included:

- Experience gained in an office environment and skills learned through work experience under the supervision of skilled professionals.
- Achievement of a variety of skills both personal and professional in nature, as well as enhanced confidence towards their professional career.
- A sense of belonging for the first time in the industry and that the experience provided them with direction within their specific career path.
- New knowledge not taught as part of standard curriculum during their construction management degree at WSU.
- Knowledge gained in modern and alternative construction techniques and how the techniques linked to theory.
- Recognised future opportunities in their employability in both local and overseas markets.
- Experience gained in BIM modelling software.
- Strengthened interpersonal and communication skills in the workplace.

Employer Survey Report

Industrial partners were also surveyed online and they were pleased with student work efforts and the feedback received. All students completed their internship satisfactorily with four out of the five survey responses indicating they would recommend the program to other organisations. Three out of five industry partners said they would participate in the program again, two were undecided.

There were some negative comments from one Industry Partners as two students failed to inform their supervisor about their absence from work on one occasion.

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Student Responses

The program proved to be popular among CM students though students had a hard time adjusting in the first week of their internship. Despite the hardships related to a new culture and language barriers, students showed resilience, adaptability and a positive mind-set which allowed them to further problem solve and gain the most out of their experience. Students enjoyed the Hong Kong program and gained outstanding practical skills in project management and hands on experience with building construction projects in Hong Kong's construction management sector. It is worth mentioning that the proportion of Australian students with an international study experience increased from 8.8% of domestic bachelor degree graduates in 2008 to 16.5% in 2014 (AUIDF, 2014). This is comparable with the United States undergraduate participation rate of 14.8% in 2013-2014 (AUIDF, 2014).

CONCLUSION

Interviews with students and information from their reflective reports indicated that the outbound students experienced new understandings of their own discipline. They had greater understanding of the difficulties in construction and construction processes beyond that available locally. Outbound students also felt they had improved their employability and global knowledge through participation in this program. The greatest gain identified was the initiation to global networks and professional contacts within the construction discipline. Anecdotal feedback also indicated the project was a transformational experience for all participating students. New understandings, skills and knowledge not covered in current domestic curricula were highlighted by the students as one of the successes of the project. The opportunities arising from discipline and professional networks, was also considered to be invaluable. Future employability was noted by a number of the students as a vital outcome. The Construction Management Department of the Western Sydney University was also able to make valuable industry connections in Hong Kong. This case study created opportunities for professional development and improved industry skills and knowledge for students and staff. It is likely the new partnerships with the host companies will be continued and the possibility of BIM related exchanges across the CM discipline further developed.

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MODELLING GREEN TECHNOLOGY ADOPTION BASED ON SUSTAINABLE CONSTRUCTION PRACTICES

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ABSTRACT

New digital technologies have the potential to monitor the environmental footprint, mainly Carbon emissions. However, the construction projects slowly adopt such technologies only for monitoring the footprint and other sustainability purposes. Despite the government's policies and external pushes, the adoption decision for sustainability innovations largely depends on different stakeholders' behaviour including developers, consultants, and contractors. This paper presents a novel conceptual model for green technology adoption regarding sustainability in the construction industry. This model is developed based on six main constructs include organizational facilitating conditions, expected performance, expected efforts, innovativeness, optimism, and user performance.

In order to develop the model, factors affecting the green technology adoption process are identified, a questionnaire is designed, and an empirical investigation is conducted to collect data from construction companies. Regression analysis is utilized to analyse the data using SPSS. The findings show the importance of a series of factors influencing sustainable technology adoption. Based on the extensive review on the relevant literature, few empirical studies have been conducted to examine the proposed constructs sustainable technology. The results are also providing a guidance to broaden understanding of users' adoption behaviour within this context and thereby increasing the chances for successful adoption of sustainable technology and develop activity-level.

Keywords: Construction Projects, Green building, Sustainability, Technology Adoption Model

INTRODUCTION

Legislated regulations of different governments for protecting the environment put the construction industry under pressure to consider the

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principles of sustainability. Organizations should decide to apply new technologies and meet sustainability requirements in all process of the project life cycle to be competitive in the industry (Petri et al., 2014).

Digital technology is known beneficial for sustainable practices particularly in the construction and maintenance period (Cheng and Das, 2014, Cheng and Das, 2014). For instance, Because of the integrative character of BIM (Building Information Management), it is an appropriate technology to implement sustainable strategies in construction industry (Hammond et al., 2014). Despite all the mentioned benefits of digital technology, the process of sustainable construction technology adoption (SCTA) is slow in construction. Therefore, the aim of this paper is to identify key factors influencing the construction participants' decisions to implement a green technology through development of the sustainable construction technology adoption (SCTA) model. Studies on SCTA is scarce, previous studies mainly focused on construction technology adoption covering a wider range of technologies (Son et al., 2015, Succar and Kassem, 2015), while the literature ignored to particularly focus on sustainable technologies.

The paper first systematically reviews the relevant literature. It follows with presenting how the literature of digital technology applications is growing while the number of publications focus on green technologies has remained constant in the last three years. In this study, TAM (Technology Acceptance Model) was used to investigate the green technology adoption in construction industry; TAM was extended to SCTA model to include organizational facilitating conditions, innovativeness, optimism, and user performance. Next, the research design and approach is presented. Finally, the results of the study are discussed.

LITRATURE REVIEW

A Systematic Review of Technology Clusters

A systematic review is conducted to identify the publication trends and to clarify the gap in the literature of digital construction technology. All papers from five selected journals were reviewed and analysed. The papers were classified into two main clusters: non-green technology and green technology.

None-green technology refers to non-green specific technology cluster included the papers which were about the digital technologies such as a description about them, their advantages, disadvantages, their applications in the construction industry, and their acceptance model while none of these technologies were toward sustainability goals.
Green technology cluster refers to a collection of papers that were about the green and sustainable digital technologies application, features, advantages and disadvantages and the consequences of their usage and

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the impact of their utilization on the reduction of environmental issues. Figure 1 demonstrates the number of papers in two non-green specific technology and green-based technology clusters in three recent years. It illustrates swift increase in the amount of non-green specific technology researches from 2014 to 2016. By technology improvement, it can be predictable that, this growing trend will continue in next years; but, despite of the increasing attention of the public and companies to sustainable development, this figure shows that, the focused researches on green technologies are insignificant, also Figure 2 shows that number of researches in the field of green specific technology is limited in compared to non-green specific technology; therefore, given the importance of applying green specific technology, researchers should be encouraged to pay more attention to it in construction industry. The results of this review presented that conducted researches in the field of green building technologies are limited and no research has been done on the application of this technologies in construction industry.

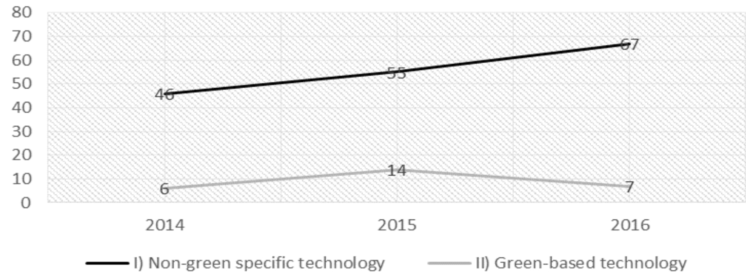

Figure 1 Total number of related publications in last three years

Figure 2 Related publications in the selected journals

According to the reviewed papers, following four main themes were recognized: 1) Off-line digital technologies; 2) BIM based technologies; 3) Web-based technologies; and 4) Green technologies, which are reviewed in next sections. Four themes are identified in the reviews which are summarized in Table 1.

Table 1 Descriptions of each identified theme

Theme	Definition	Example
1: Off-Line	Technology which related to various	CAAD for computer graphic drawing

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Program	disciplines integrated utilization such as computer science and architecture science (Yang, 2011)	and editing graphics by electronic stylus (Yang, 2011)
2: BIM Based Technologies	It's a set of innovative technology, processes and policies that influence on the deliverables, relationships and roles of the industry (Succar and Kassem, 2015)	Create and use digital models, for designing construction and managing operation of the construction process and finally performing the project life management (Jiang and Lei, 2014)
3: Web-Based Technology	World Wide Web technology which is available over the internet and enable us to communicate and exchange information and access to data via internet (Feng, 2006)	Quadcopter that enables project managers to monitor the site, maintain the asset (Irizarry et al., 2012, Snow, 2016).
4: Green Construction Technology	The technologies which are used to achieve sustainability objectives in construction industry (Chan et al., 2016).	They help to analyse the sustainable building performance such as daylighting, energy efficiency and sustainable materials (Ibrahim, 2013).

Gap in Digital Technology Literature

While main clusters are discussed in this section, further review shows that there are three main directions in the literature regarding to technology studies: a) technology development, b) technology adoption, and c) technology implementation.
The first one is based on experiments to create new prototypes for presenting it to the construction industry or improving the accuracy and quality of common technology. The second direction introduces or applies models which are sketched based on the appointed knowledge framework such as socioeconomic and psychological models. For instance, Son (Son et al., 2015) argued that two distinct constructs (usefulness and ease of use) are positively related to an individual's behavioural intention to apply a new technology in construction. The third direction concentrates on the way of operation of the innovative technology for resolving a peculiar obstacle in construction. For example, Wang and Cao (2010) reviewed key project-level factors that affect IT performance and analysed the way these factors influence IT adaption in construction industry. In another paper the user-based innovative construction technologies implementation in Australia is studied (Shelton et al., 2016).

To investigate the influential factors on construction stakeholders' decisions for digital technology adoption, studding its limitations and challenges is an important issue which can be categorized in to the technology challenges and the problems of the digital technology' implementation. The limitations of digital technology and suggested improvements for removing them are presented in Table 2.

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Table 2 The application of digital technologies in two major groups: a) green-based; and b) non-green specific technologies

	Technology Theme	Focus and Current Direction	Limitation and Suggested Improvement

Green-based Technology	Theme 1: Off-line program	To develop a simulation tool for predicating carbon emission by virtual prototyping technologies (Wong et al., 2013)	The current tools cannot monitor construction mechanisms and evaluate the sensitivity of planning schedules
	Theme 2: BIM based platform	To generate documentation necessary required for green building certification (Ilhan and Yaman, 2016)	Limited to only a group of the BREEAM materials and compatible with ArchiCAD® software
	Theme 3: Web-based technology	To develop BIM-based web platform for green building services such as energy simulation and code checking (Cheng and Das, 2014)	Technically limited functions are delivered and cannot cover critical qualitative factors such as human comfort

Other challenges of technology adoption include: difficulty in learning and complexity in usage, requiring computer knowledge, rework problems due to data entry, cost, too many functionalities, less user-friendly characteristics, and low efficiencies are reported as key causes of the tardy technology uptake. Researches showed that disability to apply some of the technology in the primary stages of their implementation and incoherence analysis tools with key software, doubt and mistrust in data sources, industrial and institutional realized barriers, can prevent its widespread application (Lin, 2010, Petri et al., 2014, Yang, 2011).

THE PROPOSED MODEL OF SUSTAINABLE CONSTRUCTION TECHNOLOGY ADOPTION (SCTA)

SCTA models is proposed based on the initial technology acceptance model (TAM) developed by Davise (Davis, 1993). TAM includes two main constructs: perceived usefulness and perceived ease of use influencing the adoption user's behavioural intention (Venkatesh and Davis, 2000). Figure 3 presents the SCTA model and the relevant hypothesized relationships.

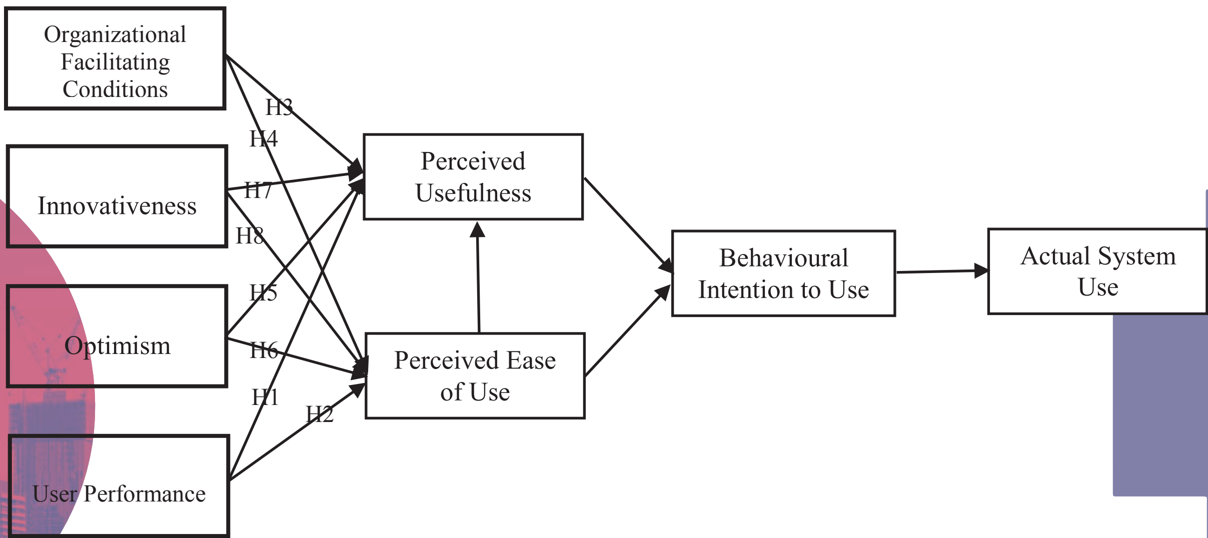

Figure 3 SCTA model of sustainable technology adoption

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In this paper we divided the factors affecting users' willingness to accept a new green technology into three main attributes: individual, organizational and the effects of the technology areas.

Table 3 Constructs of the SCTA model

Construct	Definition	Related Hypotheses
Organizational Facilitating Conditions Toward Sustainability	The comprehend availability of needed resources to apply the target technology, If support or preventive organizational factors for the use of the technology change, this environmental change should be reflected (Park et al., 2011).	H3. Organizational facilitating conditions toward sustainability affects positively on perceived usefulness. H4. Organizational facilitating conditions toward sustainability affects positively on perceived ease of use.
Innovativeness	Individuals' preference to be a technology leader, shows people realization about themselves as being a pioneer in technology adoption (Godoe and Johansen, 2012).	H7. Innovativeness has a positive effect on perceived usefulness positively. H8. Innovativeness has a positive effect on perceived ease of use positively.
Optimism	A positive opinion about the technology and believing that by technology people can have a life with more control, flexibility, and proficiency. By optimism people feel positively about technology (Godoe and Johansen, 2012).	H5. Optimism is related to perceived usefulness positively. H6. Optimism is related to perceived ease of use positively.
User Performance	The proficiency of a user in executing a duty, which refers to the precision and pace aggregated over acts presented in the period of a task (Nicosia et al., 2014).	H1. User performance has a positive relationship on perceived usefulness. H2. User performance has a positive relationship on perceived ease of use.

Since using a green technology, increase the users' efficiency in different fields such as sustainability, the user would prefer to use it. It is hypothesized that user performance can affect the technology adoption. If the organizational condition is prepared for using the sustainable technology; for example, the senior manager encourages toward sustainability and if needed resources such as sustainability software and standards are provided, the user will tend to apply the green technology; so, we hypothesized that organizational facilitating conditions toward sustainability will have the positive effect on green technology utilization. Individuals' attitude toward the use of technology and sustainability issues impact on their willingness to use the green technology; therefore, optimistic users are more likely to use sustainable technology than pessimists. Hence, we hypothesized that optimism will have the positive effect on green technology utilization. Innovativeness refers to Innovative people who prefer to try new things such as new technologies, they are

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not afraid to take risks; so, they have a positive approach towards technology adoption. Therefore, the positive relationship between innovativeness and green technology usage was proposed.

RESEARCH METHOD

This paper studies different construction participants who use green digital technology in their projects. The survey is designed in two sections. In the first section demographic information such as gender, age, education level, job title, and tenure with the company was gathered. In the second section the respondents were asked to indicate their level of agreement with 42 different statements (the measurement items) on a five-point Likert type scale, with 1 displaying "strongly disagree" and 5 displaying "strongly agree" which were adapted from previous studies. These measurement items are grouped according to the six main constructs (organizational facilitating conditions, perceived usefulness, perceived ease of use, innovativeness, optimism, and user performance). For analysing the data to measure the relations of structures through significance values Regression analysis was done using SPSS. Finally, a number of open ended questions were asked from the respondents to express their opinions.
A total of 80 construction project participants from different construction companies were selected. Sustainable construction is a priority in these companies. A questionnaire was designed for data collection, sufficient description was provided to prevent the misinterpretation by respondents. All of the respondents had experience using sustainable construction digital technology. Of the respondents in the survey, about 53% were men and about 47% were women. 100 %of the respondents had university degree. They were aged between 25–50 years.

RESULTS

In this study the effects of the four independent variables such as organizational facilitating conditions, innovativeness, optimism, and user performance on the internal factors are studied. At first the Cronbach's alpha was assessed to test the internal consistency as a measure of reliability for each sub-scale. Nunnally (Nunnally, 1978), suggests that alphas above .70 for group analyses are acceptable. The Cronbach's alpha is .708 and it is acceptable and no item shouldn't be excluded.
The Regression analysis was also conducted to estimate the relationships among dependent and independent variables, if Sig. in Coefficient is less than 0.05, the correlation is meaningful. The Beta analysis shows the amount of dependent variable impact on independent variable.
The summary of the results of assessment from the Regression-analysis is illustrated in Table 4. Individual coefficients for the assumed relations among the variables showed that organizational facilitating conditions,

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innovativeness, optimism, and user performance have a significant influence on perceived usefulness and perceived ease of use; therefore, all of the hypothesis were supported by the results. Moreover, the strongest predictor of both perceived ease of use (Beta =.543) and perceived usefulness (Beta =.538) is optimism.

Table 4 Results of the Regression analysis of independent variables and dependent variables

Independent Variables	Dependent Variables	Beta	Sig.
Organizational Facilitating Conditions	Perceived usefulness	.285	.003
Innovativeness	Perceived usefulness	.338	.002
Optimism	Perceived usefulness	.538	.000
User Performance	Perceived usefulness	.401	001
Organizational Facilitating Conditions	Perceived ease of use	.247	.004
Innovativeness	Perceived ease of use	.383	.001
Optimism	Perceived ease of use	.543	.000
User Performance	Perceived ease of use	.299	.003

Accordingly significant positive relationship between all the independent variables and perceived ease of use and perceived usefulness was detected. Based on the results, positive relationship between user performance and two dependant variables expresses that if a technology improve the performance of a user, he or she finds it more useful and if it could increase his or her efficiency it indicates that it is easy to use the technology.

The positive relationship between optimism and two dependant variables means that optimism about the technology in people causes that they find it more useful and more easy to use.

The significant positive relationship between organizational facilitating conditions and two dependant variables implies that if the needed technological and organizational resources are available, the individuals will encounter with fewer obstacles in the use of technology so they will find it more beneficial and easier to use.

The positive relationship between innovativeness and two dependant variables suggests that innovative individual can use a technology easily but unlike the findings of Godoe & Johansen (Godoe and Johansen, 2012), the results show that innovativeness causes people has a positive opinion about the usefulness of a technology, maybe because of innovativeness they can apply the technology for different working goals and in their desired ways.

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CONCLUSION

The paper is aimed to identify key factors influencing the implementation of sustainable technology in construction projects. A survey was conducted to measure the participants' perception towards new sustainable technologies. Sustainable technology refers to upgraded tools and equipment which can consider environmental concerns. Previous studies mainly focused on the technology adoption process, and have ignored to mainly study sustainable technologies (other than materials). This on-going study indicates that technology awareness and introduction to the market is the main key factor. In addition, organisation attributes including their facility and readiness play an important role in the process of technology adoption. Furthermore, cultural change is required because the company would amplify individuals' innovativeness to apply new technologies in a right way. It also may influence their optimistic about the new technologies, since optimistic users find the new technology easy to use and more useful. The findings of the study are critical for the policy makers to understand how to facilitate the process of sustainable technologies in the industry. In addition, the findings of the study help sustainable technology vendors to get better understanding of their customers. The future direction of this study is to examine the proposed model using a large data set.

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TOWARDS MANAGING ITERATIVE CHANGES IN BIM COLLABORATION WORKFLOWS

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ABSTRACT

Collaboration on Building Information Models (BIMs) requires iterative and distributed processes that make maximum reuse of the information being exchanged directly between models in a platform independent model collaboration environment. As the information in a BIM grows during an iterative design and production process and even beyond into maintenance, a critical issue is how to manage the iterative changes because of the collaboration operations and workflows that involve various project participants and heterogeneous applications. This paper highlights the overall problem of managing iterative changes in BIMs and discusses various issues and challenges involved in controlling the collaboration transactions on a BIM data repository in a multi-model collaboration environment. This positional paper describes that model matching and comparison strategies are the keys to solve the problem of iterative change management, which may have better solutions in other knowledge domain such as software engineering. The future research is exploring Software Source Control (SSC) strategies to devise a signature-based model comparison approach for IFC models that can lead to potential solutions for effective management of collaboration operations with BIMs.

Keywords: BIM, IFC, Model Server, Model Comparison

INTRODUCTION

The technology to efficiently create Building Information Models is now mature and can support the development of discipline-specific building information models; however, the technology to collaborate on models is still developing and growing. Collaboration on BIM models involves iterative and distributed processes that make maximum reuse of the information being exchanged directly between models in a model collaboration environment. BIMs are subject to constant evolution, where

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collaboration requires information to be created, coordinated and exchanged concurrently and most often in real time, allowing multiple users to manipulate information whilst requiring the data to be synchronised in a shared data repository. As the information in a BIM grows during an iterative design and production process and even beyond into maintenance, a critical issue is how to manage the iterative changes as a result of the collaboration operations and workflows that involve various project participants and heterogeneous applications. Emerging practice indicates that the aspirational single project model in a collaborative BIM environment is not usually a single database structuring all the related information but a combination of tightly and loosely coupled databases (federation) linked with clear rules and allowing controlled access to the different parts of the information available in the federated model for collaboration operations. A central issue to the management of this federation is an understanding of the concurrent and iterative processes required to support and execute tasks involved in the operations of a collaborative BIM environment.

LIMITATIONS OF CURRENT BIM COLLABORATION PRACTICES

Collaboration on Building Information Models (BIMs) is currently undertaken through file-based exchanges, using a variety of methods, such as physical file transfer, extranets, project websites and proprietary collaboration tools (Isikdag et al. , 2007; Shafiq et al., 2012). A file-based collaboration on BIM models have several limitations (Adachi, 2001; Hietanen, 2002; Kiviniemi et al., 2005; Beetz et al., 2010), and thus offer limited opportunities to manipulate the data (Shafiq et al., 2012).

- Differences in the internal storage structure of BIM authoring platforms (e.g. Autodesk Revit, ArchiCAD) make it difficult to maintain the integrity of information in models when shared between applications. Even if the exchanges are in a platform-neutral file format, such as Industry Foundation Classes (IFC), native BIM authoring applications leave application imprints on the data. Moreover, the addition or loss of data during an IFC export may result in models becoming less interpretable once imported into other applications.

- Redundant data may occur in different versions in file-based model exchanges leading to data duplication and rework.

- As the information content grows within a BIM, its size significantly increases, which results in it becoming difficult to transfer through a file exchange mechanism.

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- In many cases, only a partial view of the model is required to be exchanged or viewed due to data ownership and liability issues, which is difficult to manage through file based exchange.

- Maintaining proper versioning of objects is impractical in ad-hoc file based model exchanges. Controlling user rights, ownership and responsibility of the model's contents become compromised in a file-based information exchange.

Therefore, use of file-based exchanges of data to collaborate on BIM models is not a long-term solution to facilitate acclaimed benefits of using Building Information Modelling. In addressing this issue, the concept of model servers was introduced as a potential solution to improve the workflow and stimulate collaboration on BIMs. However, research has been limited to date in this fertile and emergent area.

BIM COLLABORATION AND MODEL SERVERS

The technology that can support database level exchanges is generally referred to as 'model servers', which can exploit and reuse information directly from a shared model repository and facilitate collaboration among any number of participants. Plume and Mitchell (2007) and Jørgensen et al. (2008) define model server as a type of database system that allows upload, download, sharing and coordination (e.g., model comparison, and model checking) of models or components by multiple users. Attempts to develop model servers for the construction industry started alongside the development of Industry Foundation Class (IFC) schema (Adachi, 2001, 2002). The IFC schema is independent of mechanisms or tools used to generate data; its focus is to represent the core data of building components as object models. Thus, for database level transactions, the complete 'IFC data model' can be used to underpin a 'model server', which has been referred to as an 'IFC model server' (Adachi, 2002; Hietanen, 2002).

A BIM hosting model server is expected to facilitate the exchange of information between the applications used throughout a building project lifecycle (e.g., design tools, analysis tools, document management systems, facility management tools) used throughout a project's lifecycle (Singh, Gu, & Wang, 2011). The potential of 'model servers' coupled with web-based technologies for effectively enabling information to be shared in a collaborative environment has been demonstrated (e.g., Kiviniemi et al., 2005; Jørgensen et al., 2008; Beetz et al., 2010). A considerable amount of research has been undertaken to develop model server capabilities through the use of the Standard for the Exchange of Products (STEP), IFC, as well as proprietary data formats, resulting in products such as IMSvr, SABLE, Express Data Manager (EDM), Share a Space,

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Activefacility and BIMserver (Adachi, 2002; SABLE, 2003; Beetz et al., 2010; Shafiq et al., 2012).

Model servers are the backbone technology that can enable the realisation of effective collaboration on BIMs, though they are still not technically mature. A platform independent model server should allow different discipline BIM applications to exchange data using IFC, and provide collaboration functionalities to enable a model to be uploaded/downloaded, viewed, split, merged, and compared. However, the collaboration workflows during model server transactions result in the creation of complex data structures, the management of which has several unresolved challenges, therefore limiting the practical application for end users (Kiviniemi et al., 2005; Koch and Firmenich, 2011). Consequently, there has been a tendency for them to be used within experimental and academic environments, due to a number of latent 'pitfalls', such as IFC export/import quality, access control and change management etc (Hjelseth and Nisbet, 2010; Jørgensen et al., 2008; Kiviniemi et al., 2005; Kiviniemi, 2006b; Singh et al., 2011).These problems are not solely attributable to the limitations of the technology but the inherent structure (e.g., procurement methods and contractual arrangements) and complex works flows and procedures that have been designed to deliver projects in a linear workflow.

Iterative Change Management in a model server workflow

A critical issue in managing collaboration operations on a model server is the management of iterative changes during BIM collaboration operations. The shared data repository on the server must be updated with any changes because of modifications made in a check in/check out the operation, such as new data instances added, deleted or changed.

The information in the shared repository (i.e. Model server) is defined in terms of a moment in time and associated versions in other moments in time, resulting in several versions and variants of a shared repository instance and discipline-specific information models. The changes in these versions can be; (1) technical changes, such as selection of a design alternative; (2) modifications and detailing of objects as the design process precedes; (3) changes caused by data round-tripping, such as IFC import/export. Management of these changes, (1) & (2), involves complex workflows supported by computing operations which enable a model server to handle simple and complex transitions. Apart from the technical challenges, there are user issues that need to be considered while managing iterative changes, however, this is outside the scope of this research.

The analysis, interrogation and collaboration of BIMs is generally reliant on the use of Globally Unique Identifiers (GUIDs) or arbitrary geometry representations, however, there is a tendency for both to fail in the

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complex situations arising as a result of simple and complex transactions in a model server environment (Liebich et al., 2010). Furthermore, support is required from the client side application when submitting changes to the model server, for example, to maintain object owner history and the consistent preservation of GUIDs. However, the internal data storage structures of client side BIM applications tend to be different from each other, with limited support for database level change management within proprietary BIM applications for server enabled collaboration.

For example, if a structural engineer decides to change the position of 4 columns, there is no predefined standard workflow for executing this change. The engineer may change each column individually, leading to four changes in the model; or may decide to change one, delete the other three and then copy and paste the first one three times (Figure 1). This will result in one change, three deletions and three new columns in a model, but ultimately the design change would be the same in both cases.

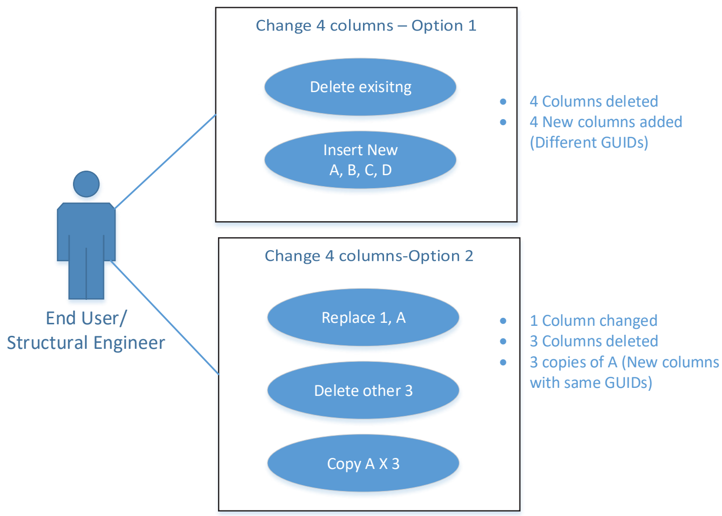

Figure 1: Use case of a structural engineer modifying columns

In similar design modifications, as represented in the use-case example in Figure 1, when exporting the latest version of an IFC model, the IFC versioning can be different as well as the associated GUIDS, leading to two different comparison result under the same editing option.

If the objects' GUIDs are identical, there is clearly a match for comparison or merging (as GUIDs are designed to be unique). However, two objects can still constitute a comparable pair even if their GUIDs are different. Most model comparison applications, such as Solibri or ArchiCAD, use GUIDs to establish candidates for comparison and therefore fail if they are different for two comparable objects. Tracking comparable objects across versions is the most basic operation in managing the workflows of model server enabled collaboration on BIMs. GUIDs are helpful when tracking

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such changes, but there is a need to consider other characteristics in addition, such as location (same bounding box), containment (same address), name, specification, or function of the objects to perform a more meaningful comparison.

Also, when managing changes in model server environments, it is important to understand what types of changes are expected in two versions that are being subjected to a comparison process. In addition to obtaining an accurate comparison result, the process should minimise a number of unwanted change notifications to the end users. Model comparison is performed at an object level but the end users are typically concerned about the effectiveness of the outcome. For example, when a cost engineer runs a model comparison, if there isn't any change that affects cost information, then he or she may not be interested to know anything else that is different between the two versions of the model.

So, in terms of managing changes in IFC models, it is important to understand the scope of changes at an object level, but also to consider the end user requirements (e.g. comparing heating systems only), otherwise, the comparison process may produce accurate, but redundant results for the end users. A practical way of thinking about change management in the construction industry is linking a change to its subsequent actions, such as a design change leading to a new set of drawings or a specification change triggering a 'Request for Information'. These changes can affect the objects inside a model by changing their position, shape, and properties. If the position and shape of an object are changed, then it is a visible change and so can be communicated to an end-user through a graphical representation (i.e. a door has been moved from wall A to B).

CREATING SIGNATURES FOR IFC OBJECTS: A WAY FORWARD

Signature matching in Software Source Control

As argued in the previous sections, Model comparison strategies in IFC model comparison are heavily based on GUIDs, which have some limitations in providing accurate results. This comparison mechanism is called "static ID based matching approach" that suggests that each object in two comparing models has been assigned a unique identity upon its creation, which is a persistent and a non-volatile unique identifier for an object. This unique ID is referred as GUIDs or Universally Matching Unique Identifier (UUIDs) in software engineering. Software source control (SSC) is a similar process in software engineering that facilitates multiple-user database level collaboration in an environment like model servers. However, in SSC, comparison of two potentially matching objects is not limited to using a static ID based matching algorithm. In addition, a signature based, a similarity-based or a language specific matching

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algorithms can also be used to address inherent limitations of a static ID based matching and comparison algorithm (Kolovos et al, 2009). This study has analysed SSC comparison algorithms and has identified that a signature based matching approach can be applied to IFC model matching and comparison in model server collaboration transactions.

Reddy & France (2005) proposed a signature based matching approach in which the identity of an object is not static but calculated dynamically from the value of its properties and attributes creating a unique signature for an object. Oliveira & Breitman, (2009) defined that "the signature is the collection of values assigned to a subset of syntactic properties in the model elements". The set of values that can be used to determine a signature for an object is called "signature type" (Reddy & France, 2005). Furthermore, Oliveira & Breitman (2009) divided signature types intro three categories, which are; (1) a complete signature that covers all the syntactic properties associated with a model element; (2) a partial signature that covers a certain range of element properties; and (3) a default signature that is only composed of name properties. The selection of a signature type for an object requires user configuration which can be defined using a query language. A signature can be calculated using any number of properties associated with an object that can provide a distinguisher for the object. For example, a signature for an object can be its name, type and location or a combination of these characteristics (e.g. wall, wall type, position coordinates).

A signature of an object does not rely on a precedent identity (e.g. GUIDs); therefore, it can also be applied to the models which are created independently of each other using different tools (i.e as in the case of IFC models populated from Revit or AECOsim). However, the creation of unique object signatures requires developer and end-user involvement to define a series of functions to calculate accurate signatures for model objects based on their signature-types. Once a user defines the set of values of signature calculation, a hash value can be computed for the relevant properties sets which are used to establish a match during the comparison process. A hash function is used to map digital data of arbitrary size to digital data of fixed size, the values returned by hash functions are called hash values or hash codes or hash keys or simply hashes (Carroll & Krotoski, 2014). Signature matching is useful even if a complete solution is not feasible with signature matching, as signature matching can be used to eliminate a significant proportion of elements to downsize the comparison criteria for any further comparison.

Signature matching application in IFC models

The characteristics of objects can be used to create signatures for IFC objects, which then can be used in addition to GUIDs, to effectively compare corresponding objects in change management process. This leads to a new research question: "What should constitute an effective

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signature for IFC objects?" It is suggested that this can be answered by considering the structural and semantic characteristics of an IFC model and the type of changes an IFC object can undergo. Fundamentally, a change can be in (1) an object's position, (2) its shape and its (3) properties.

Position and shape are absolute, as any change in these components will require a significant change. Therefore, the characteristics of an object related to its position and shape provide an appropriate mechanism for creating recognition signatures.

> For example, in an 'IfcDoor', the 'IfcLocalPlacement' defines the local coordinate system that is referenced by all geometric representations. The three-dimensional (3D) shape of 'IfcDoor' is represented using 'SweptSolid', 'SurfaceModel', or 'Prep' to define the door geometry. Most BIM authoring tools exchange arbitrary shape extrusions in IFC, which can be used to create a unique object signature.

Creating a signature from element properties is complex, as properties have a degree of change and how that change is important in term of a comparison result and in the context of change management from an end user's perspective

> For example, in versions A & B of the same IFC model, change in properties can have following scenarios
>
> Properties of object A (version 1 of a dataset) = P [A]
> Properties of object B (version 2 of a dataset) = P [B]
>
> P [A] = P [B] = No change in properties
> P [A] > P [B] = some properties have been deleted
> P [A] < P [B] = some properties have been added
> P [A] ~ P [B] = Properties have been updated/edited

Therefore, it is important to determine what properties are important and if we can determine the degree of importance in IFC properties, then it can be used to create a signature based on the key properties. Several signatures can be created from object properties, such as (1) The total number of property count can be used as a signature; (2) A name key for all the property sets names attached to an object can be used as a signature; (3) A name key of property names can be used as a signature and (4) A property value key can be used as a signature etc. These signatures can be used as passes to determine the degree of change in a potentially matching pair in a model comparison process.

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In summary, the position and shape are a way of reflecting an object on a drawing and in a 3D model, which is easy to reflect an end user if there is any change. Therefore, these two components are compelling candidates to create a unique object signature. However, the case with object properties is different as it involves the degree of change that needs to be incorporated into creating the signature.

LIMITATIONS AND FUTURE WORK

This study has proposed that the characteristics of an IFC object can be used to create unique signatures for IFC objects, can be used in addition to GUIDs, to effectively compare corresponding objects in change management process in model server collaboration transactions. An object's position, shape and properties can be used to formulate partial, default or complete signature for an object, which can be used as passes to establish candidates for comparison and to highlight changes in a comparable object pair.

In terms of creating an element's signature, there are several issues that need to be considered in the broader perspective of change management in a model server environment. A change or update in an object's properties can have multiple impacts, for example, it can affect its identity, position, shape, representation, subsequent drawings and specifications or both for the end user. As previously noted, the position and shape related properties of an element are strong candidates for a signature but the those remaining also need to be examined and cannot be ignored if effective change management and productivity improvements are to be attained, particularly during the model comparison process. Also, an important issue is to consider is associated weighting of different signature-type attributes of IFC objects to constitute an effective signature for IFC objects. Future research will focus on creating object signatures using hash codes from IFC object characteristics, to formulate an object recognition and comparison strategy in managing model server enabled collaboration on BIMs.

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INDIVIDUAL RISK ATTITUDES IN POSTGRADUATE RISK MANAGEMENT EDUCATION

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ABSTRACT

Risk management is important for contemporary construction organisations, and is a vital constituent of project management education. Before learning about the processes of systematic risk management, construction and project management students need to better understand risk concepts and their own attitudes towards risk. Risk is a psycho-social construct experienced and perceived by individuals. In the Risk in Construction subject offered in the Master of Construction Management programme at the University of Melbourne, students were first invited to respond to a simple questionnaire that measured their own risk attitudes from a task, team and individual risk perspective. This self-knowledge discovery was then applied in their subsequent individual and group assignment work for the subject. The risk profiles were also used in a novel approach to assignment group formation. Students valued the opportunity to explore the alignment between formal project risk management and their own risk attitudes, and used their newly-found understanding in other management-related subjects. Future research will explore cultural and gender influences in these student journeys of self-understanding.

Keywords: Assignment groups, construction management, education, risk management.

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INTRODUCTION

Risk is defined as: "the effect of uncertainty upon objectives" (ISO31000, 2009) and nowhere is this more exemplified than with construction projects, since they are conceived, designed, planned, and implemented with many uncertainties associated with the decision-making surrounding the process elements; yet with the intention of fulfilling stated objectives and thus facing risk (Parkin, 1999). While the given definition is neutral, risk may be framed positively or negatively in its effect. In practice, most organisations use risk management proactively to protect objectives from adverse outcomes (threat risk), rather than seeking windfall gain (opportunity risk). While all projects are susceptible to risk, some carry more risk than others. Factors which influence the nature and level of threat risk include: complexity; scope and size (Flyvbjerg et al., 2003); stakeholder inexperience; severe time and cost constraints; and technology which is unfamiliar to the user. Such risks are themselves shaped by intrinsic or extrinsic drivers that may be physical, technical, economic, or social in nature (Russell and Nelms, 2007). Edwards *et al.* (2009) describe systematic project risk management as a proactive process, embracing formal activities that: establish the context (both internal and external); identify, analyse, and respond to risks; monitor and control risks during project execution; and (importantly) capture and manage knowledge of project risks effectively. The decision-making associated with the four essential elements of all projects (tasks, technologies, resources and organisation) provides the basis upon which risk management is implemented and directed (Edwards and Bowen, 2005), but for different project stakeholders these elements, and indeed the objectives sought for the project, will themselves be different. Hence each project stakeholder bears responsibility for managing its own risks, and a single project risk management system common to all stakeholders is impractical, even though there should still be mutual understanding of other stakeholders' risks.

Risk is a *psycho-social construct*: it arises from an individual's perception of what constitutes a risk and how great the magnitude of that risk might be (Slovic, 2000). Such perceptions are influenced by the cultures in which we exist, through societal norms and attitudes to risk. Furthermore, each of us may have personal risk attitudes that are consonant with, or differ from, our professional risk attitudes. A construction manager may be risk averse personally and professionally; risk seeking privately but risk averse professionally; risk averse privately but risk seeking professionally; or risk seeking in both life dimensions. Unless the two opposing risk attitudes, in both personal and professional dimensions, are known and acknowledged by the individual and by the employer organisation, difficulties may arise for project risk management. However, while individual risk attitudes may change over time, professional risk attitudes are likely to remain relatively stable, and are usually found to be risk averse. Individual risk attitudes translate into organisational risk perspectives through the power of key decision-makers. It is thus possible for one part of a construction organisation to exhibit a different risk attitude compared to another part of the same organisation. However, such dissonance is unlikely to persist since senior management will seek to establish and adhere to uniform risk policies across the organisation. Risk awareness is an important pre-cursor to this (McLucas, 2003).

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Thus, while formal risk management should form a substantial topic in the curricula for construction and project management programmes, and be infused in the syllabi for other management-related courses and programmes, it is also vital that students be encouraged to develop deeper insights into their own attitudes to risk. The aim of this paper is to describe how this was attempted in the Master of Construction Management (MCM) programme offered at the University of Melbourne, and how that self-understanding can be used in the formation of groups for subject assignment purposes.

THE CONSTRUCTION & PROJECT MANAGEMENT PROGRAM CURRICULA

The topic of risk management can be found in many graduate education programmes around the world. It is essential for diplomas and degrees offered in project management, given the nature of projects described earlier and the need for students to acquire knowledge and develop expertise relevant to their careers. In the Master of Construction Management (MCM) program offered at the University of Melbourne, the focus is on the construction industry, especially in terms of projects and people-based activities. The concept of leadership is strongly implemented throughout the program due to the nature of construction management roles, and to enhance the employability of graduates. Within this leadership perspective, however, the emphasis is placed upon team risk management. This reflects similar global initiatives for construction-related degree programmes, developing individual capacities but also in a team environment for group and project-based tasks (Olawale, 2015, Arrowsmith et al., 2011).

The MCM at the University of Melbourne (UoM) is normally a three-year degree but, with advanced standing from an undergraduate construction degree, students can achieve the award in two years. Each academic year consists of two twelve-week semesters, and the program offers specialised streams in Project Management, Cost Management and Building. The MCM is essentially a professional degree, for students already holding an undergraduate degree, to prepare leaders for the construction industry. The program uses a case study approach covering the whole life cycle of a construction project from initial concept to delivery of the finished building and on into its operational life. Using the perspectives of client, design team (architects and engineers, quantity surveyors, project managers, etc.), contractors, sub-contractors, finance providers, users, and facilities managers, it prepares students for the realities of professional life. Reflecting the level of involvement of these project stakeholders in graduate programmes in this way is directly related to high levels of employability (Tran, 2015), bringing academia and industry closer together. In a recent study on employability for construction project management degrees, carried out at the Aston

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University in the UK, 14 skills were identified as critical skills and competencies. Of these, Olawale (2015) found that for project management graduates, employers seek team-work most of all, followed closely by verbal communication, written communication, leadership ability, and flexibility.

The MCM program focuses on five main skills development areas: technical understanding of design and build processes; understanding construction project delivery to meet client expectations (such as costs, time, aesthetic and functional requirements); analysis, evaluation and allocation of risks, and achievement of value; using various methodologies for problem solving and developing capabilities in research, analysis, evaluation and discussion; and developing strong skills, principles and practices in team management and motivating, coaching and leading people. The MCM aims to meet high levels of skills requirements for professional bodies in the construction industry such as the Australian Institute of Building (AIB), Royal Institution of Chartered Surveyors (RICS) and the Australian Institute of Quantity Surveyors (AIQS)[http://study.msd.unimelb.edu.au/programs/master-of-construction-management/overview].

TEAM-BASED ASSIGNMENT WORK

In the MCM program, many subjects involve group-based assignment work undertaken by small teams or groups of 3 to 5 students. In the past, the formation of such student teams or groups was via personal choice or as directed by the lecturer. Students knew only a few people in their class (with cohorts usually exceeding 60). Generally, they tended to form a group with known friends without any reference other attributes such as personality type, cognitive style or risk perceptions. The assumption, for groups formed in this way, is that all members have about the same level of content specific knowledge, and the sole purpose of the group activity is to apply the knowledge learned throughout the semester simply to complete the assignment often in the most expedient way. Most groups operated in line with a basic model – groups form, they perform a task, and then they disband.

However, this does not accord with the requirements of effective team deployment which is now well documented in business and HRM literature. Miller *et al.* (1994) note a mix of personality types and cognitive styles across team members may be crucial to team performance. Greenwood (1997) is convinced that an understanding of behaviour towards risk should become fundamental to more effective management, particularly in a team context. Belbin's (1991) team role model and the Margerison and McCann (1991) team management wheel can aid the selection of individuals into teams. Such models are becoming increasingly popular among the building professions (Tennant, 2001).

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A NEW APPROACH POSTGRADUATE RISK MANAGEMENT EDUCATION

The subject

Risk in Construction is a core subject for postgraduate students enrolled in the MCM program at the University of Melbourne. It is offered in the latter part of the degree within both the "Cost Management" and "Project Management" specialisations. Since risk management is regarded as an important pillar to project management in the Project Management Body of Knowledge (PMI, 2013), the subject syllabus aims to achieve the following objectives:

- To build an appreciation of the sources and impacts of risk in construction;
- To provide the generic processes and associated theories, principles and tools to manage risk in construction in a holistic manner;
- To understand qualitative and quantitative methods in analysing risk; and
- To provide generic risk management strategies for use at site and corporate levels in construction.

Organised as an advanced seminar series, the subject exposes students to the various dimensions of risk management from a range of industry stakeholder perspectives. It comprises multiple presentations by guest lecturers, most of whom hold high level positions in industry, who can share different perspectives on risk and their risk management practices. Guest presenters include clients, developers, consultants, designers, contractors, tenants, financiers, and representatives of public authorities.

Subject assessment comprises an individual assignment, a group assignment - including a team presentation, and a two-hour formal written examination (individual). These components are arranged as follows:

- The *individual* assignment (Assignment #1) focuses on the identification and evaluation of risk in relation to a hypothetical project from the perspective of a specific project stakeholder.
- The *group* assignment (Assignment #2) is a professional report, which involves researching and analysing the risk management structure and impact of the identified risks on a real construction project scenario. Team performance is evaluated through observation of the final project presentation and a group report.
- A two-hour examination focuses on risk management theories and a range of issues relating to risk management in construction covered during the semester.

Formation of the assignment groups was based upon individual risk profiling and described later in this section.

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Proposition

Adair in Mullins (1996) notes that risk circumstances can be found in Task, Team, and Individual climates, all of which must be addressed to ensure effective project management. For the Risk in Construction subject, the proposition was formed that assign team members with different risk perceptions in task, team and individual climates would influence team performance. This research is ongoing, and this paper only reports on the method employed to arrive at assignment group formation. There is not yet sufficient data for the performance investigation.

Sample

Students taking the Risk in Construction subject come from various backgrounds. These include engineering, construction management, and architecture. Each semester, about 60-80 students are enrolled into the subject, and the risk profiling questionnaire has been administered at the start of the semester for the past three years.

Measures

Greenwood's (1997) questionnaire instrument was adapted as a tool to measure individual self-perceived behaviours towards risk in Task, Team and Individual climates (see Table 1). In her study, perception about behaviour towards risk was captured with six scenario sections.

Table 1: Climates and scenarios of the risk perception instrument (Source: Greenwood, 1997)

Behaviour towards risks	Scenarios
Tasks	Section 1 - "When taking on new work, I believe…."
	Section 2 - "How do you view failure"
Team	Section 3 - "When leading my team, I…"
	Section 4 - "As a leader, I…"
Individual	Section 5 - "I Perceive myself as…"
	Section 6 - "In a changing environment I value…"

Each scenario has eight pre-set responses describing behaviours graded from low to high perceived risk. Respondents must select one or more responses, and allocate a total of 10 points among the statements for each scenario, thereby weighting their self-perceived behaviour for each scenario. The points in each climate are totalled and further weighted to accentuate the participant's overall low to high perceived risk-taking behaviour. The relevance of Greenwood's (1997) measurement tool is shown in Figure 1.

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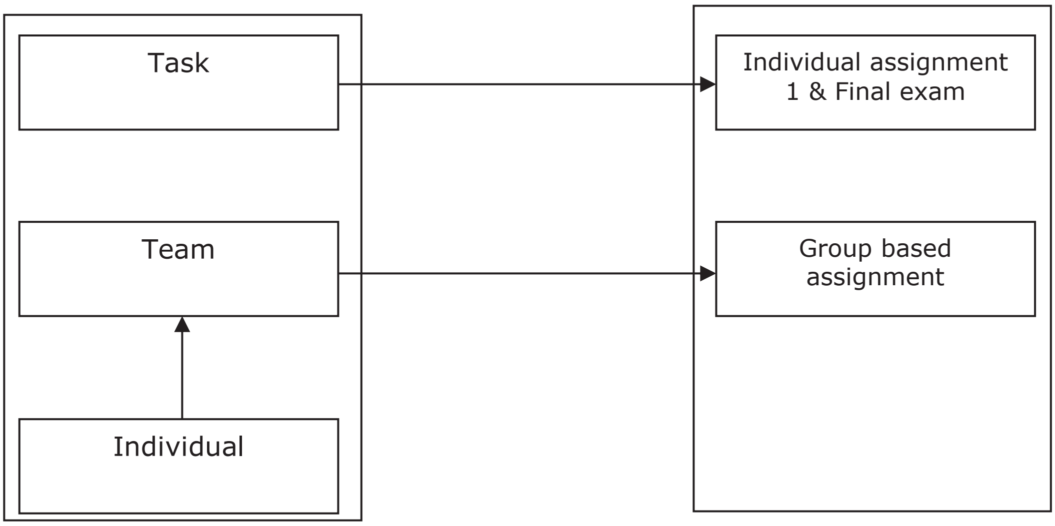

Figure 1 Relevance of the Greenwood (1997) risk profiling instrument to the MCM course assessment requirements.

Table 2 shows an example of "Team" climate from Greenwood's instrument which reflects the relevance of the measurement tool study to the discipline of project management.

Table 2 Risk profile measurement tool: "Team" example

Section 3	**When leading my team, I…**	**Keywords**
a	Always provide specific instructions	specific instructions
b	Make an effort to explain decisions	explain decisions
c	Turn over responsibility for decisions	responsibility
d	Share ideas	Share ideas
e	Closely supervise performance	supervise
f	Provide opportunity for clarification	clarification
g	Work with my team to make decisions	Work with team
h	Turn over responsibility for implementation	responsibility for implementation
Section 4	**As a leader, I…**	
a	Like to broadcast the successes of my team	to broadcast the successes
b	Trust information passed down from senior managers	Trust information
c	Encourage criticism of my leadership	criticism
d	Am likely to check information given to me by my peers	
e	Require my team to keep in touch	keep in touch

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f	Like to communicate my team's failures	Communicate failure
g	Am comfortable to delegate my leadership role	delegate
h	Only share with my team the information they need to know	share

(Source: Adapted from Greenwood, 1997)

All the statements and keywords were considered relevant and important to project management. Students assessed the relative *personal* importance of each statement by allocating scores to each one, to arrive at a total of 10 points for each section. It is acceptable for some statements to be given a zero score, or even one to get all ten points.

Outcomes

The quality of students' assignments relies on the effective participation of all team members. As a general rule, groups of four members tend to work well, and at UoM this group size is normally adopted as a maximum. The method adopted for team formation in the assignment work for the Risk in Construction subject used the following sequence:

1. At the first class, printed copies of the profiling instrument are distributed. After the subject co-ordinator has explained its purpose, the attending students complete and hand in their calculated profiles. Absentee students are followed up via email to complete their risk profile.
2. Once students have completed the questionnaire and scored calculated, each student then knows her/his own self-perceived attitudes towards risk in all three situations or climates,
3. The "Team" climate scores for the whole student cohort are then ranked from low to high. Four group "bands" are then determined. The highest 25% are considered as risk-averse, the bottom 25% as risk-takers; and the remaining quartiles allocated in the mid-ranges.
4. Students in each band then have some choice in the group formation process in that each must choose (or negotiate with) one team mate from each of the other three bands.
5. Eventually each assignment group is formed and ideally comprises at least one student from each risk profile band. The groups are then formally registered, and further changes to group composition can only be made with the approval of the subject co-ordinator.
6. The co-ordinator closely monitors assignment progress and final assignment results for each group.
7. The students are required to organise and conduct group meetings to progress their assignment.

By undertaking this group formation process it has been found that students in the subject not only gain deeper understanding of their own attitudes towards risk, but also experience working alongside others, with

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different risk attitudes, in a team environment to fulfil mutually shared assignment work objectives. This process was undertaken during semester classes and no detailed results are yet available. However, data will be collected in future years and a more systematic analysis of the results will become available for consideration. The selection for the composition of the teams for the group assignment will be done by different levels of team risks. The results will be correlated with performance in the individual assignment, the group assignment, and with the final examination. An interview with each team leader of the group assignment, at the end of the semester, is intended, based on the minutes of meetings of the group and measures to evaluate the performance of the team.

DISCUSSION AND CONCLUSIONS

Risk is pervasive in construction projects, and those who are involved in them must know how to deal with it. Projects are team-based endeavours and thus reflect the influences of multiple individual risk profiles in the decision-making processes that all projects go through. Individual risk attitudes turn into organisational risk perspectives through these processes. For students of project management, it is important for them not only to learn about risk management, but also to understand how their own attitudes towards risk might affect their individual, as well as team, performance. We have described how this is being done with students in a construction management master's degree program that also inculcates leadership and communication skills. We have proposed and implemented a new approach for teaching risk management that draws students through a self-perceived assessment of task, team, and individual risk climate evaluations. The resulting risk profiles are then used to create more balanced student groups for assignment purposes. The process aims to more closely align the recommendations of research in business and HRM with the inherent nature of project management and the stakeholder structure of projects.

Students have responded well to this approach. They value discovering their own risk profiles in various settings, and are interested in seeing how this impacts on their contribution to assignment work in groups where fellow team members have significantly different risk profiles. This first implementation of the approach has been qualitative, based on individual feedback of the team leaders of each group assignment. However, we have clearly identified that team skills to address individual risks are essential to the performance of the team results, and the importance of this to be included in postgraduate programs. Some students have then used the same approach in other subjects. Further research is planned to assess the impact of this novel approach, through a larger data-set and additional profiling factors (gender, culture etc.) on individual and team performance.

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MODELLING USER PERCEPTION OF ONLINE VISUALISATION IN REAL ESTATE MARKETPLACES

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ABSTRACT

Increased internet penetration rate has made internet marketing an integral part of real estate industry. This may result in an inefficient process for the buyers and sellers due to the need for physical inspection. The aim of this study is to present key factors influencing the users' decision to use a web-based technology for real estate purposes. This is an ongoing study including two phases: developing a framework based on a case study, and conducting a survey to measure customer perception on incorporating online visualization techniques. The paper presents the result of the first phase evaluating real estate marketing platforms as case studies in Pakistan and Australia. While the initial results show that physical inspections are still required before deciding on property transaction, it was found that the number of inspections can be reduced by incorporating a 3D model of the property to the listing platform. In addition, it was observed that clarity of search results and provision of a 3D model are some of the key factors influencing the user preference to use the website again. This reinforces the idea that advanced visualization techniques can improve the current reliability issues faced by customers and may also streamline the transactions. This study will be extended by conducting the designed survey in two target countries one a developed country and the other one a developing country to compare the most popular features to international customers.

Keywords: Online Marketing, Digital Real Estate, Smart Technology, Virtual Reality

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INTRODUCTION

Real estate agents bear the most part of the marketing costs during the process of sale and rental from advertisements to arranging buyer inspections and final negotiations. However, they only receive a tiny fraction of marginal selling price. A study based on nearly 100,000 homes, of which roughly 3,300 were owned by the agent themselves, was carried out in the US. It was found that agent-owned properties sold roughly 3.7% (or about $7,600 at the median price) higher. Also, these properties were listed for 9.5 days (approximately 10%) longer than comparable non-agent owned ones. While this difference of $7,600 is large for the consumers, the real estate agent would only make 1.5% commission on it, translating to about $114. It can be argued that an agent would find it reasonable to forgo the $114 to avoid having a client's home on the market an additional ten days (Levitt and Syverson, 2008). The results favoured the hypothesis that the real estate agents would be willing to go at lengths to convince clients to execute the transaction quickly and at the non-market value. Furthermore, real estate advertising is at times also designed to be misleading to attract potential buyers. In 2016, an article by Craze (2016) highlights one such scenario where the photographs posted on the website portray a misleading image of the property and the images appear to be tampered with. Such incidents have made customers to doubt the information that is being provided to them until they physically inspect the property themselves (Craze, 2016).

Interestingly, visualization techniques present a unique opportunity to overcome such integrity issues in online real estate marketing. The paper therefore evaluates 'RealEstate', a selected online real estate marketplace in Australia and compares it to 'Zameen', a similar website in Pakistan to study user reception of incorporating visualization tools. Table 1 shows a comparison of key indicators between these two markets. While Australia has a well-developed and well-managed real estate industry, Pakistani market is yet to achieve such development. However, a much larger population and a significantly larger internet user base provides a greater potential benefit for early adopters of visualization techniques in Pakistan compared to the same in Australia.

Table 1 A comparison of key features of Australia and Pakistan

	Pakistan	**Australia**
Real Estate Market Size	AUD 700 billion (Janjua, 2015).	AUD 6 triillion (Tan, 2016).
Area (km2)	881,913 (Worldatlas, 2016).	7,692,024(Geoscience Australia, 2017).
Population	201,995,540 (CIA, 2017).	24,413,700(ABS, 2016).
Internet users	34,342,400 (InternetLiveStats, 2016).	20,679,490 (InternetLiveStats, 2016).

LITERATURE REVIEW

This section reviews the related literature in two principal areas namely; visualisation technology and online real estate marketing. While previous studies investigated 3D modelling for various stages of construction

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including design and asset management, little is mentioned on application of such visualization techniques to online property marketing. A study highlighted the integration of BIM and 3D laser scanning technologies to streamline the user experience in real estate services. The research went on to study the possible synergies of BIM and 3D laser scanning to come up with more comprehensive as-is building data and further advantages of this integration to the real-estate industry (Mahdjoubi et al., 2013). Moreover, the studies have also modelled visualization techniques to simulate inaccessible areas in conflict afflicted regions for urban planning and real estate purposes (Far, 2015). Furthermore, researchers have explored the possibility of using mobile phones for creating 3D models and developed a technical framework to incorporate various stereo-based depth hypotheses into a realistic 3D model (Kolev et al., 2014).

The review of previous literature and publications in visualization technologies shows that a lot has been studied on the techniques and their application. However, customer feedback and perception on such applications in online real estate marketplaces and e-commerce has been missed. This paper tends to bridge that knowledge gap by identifying on what is missing in the current online real estate marketplaces and how customers react to the idea of incorporating the advanced visualization techniques.

A study on online real estate marketing conducted in the US during 1999 found that residential properties listed on online marketplaces remained 11% longer and were sold about 1.93% more than those not listed online. This translated to roughly six more days of marketing and resulted in a premium of around $2900 for the average house. Thus the sellers would benefit the most by listing their properties on the internet (Ford et al., 2005). Furthermore, studies have argued that while the real estate market was experiencing a dramatic rise with about 5.56 million existing single family homes sold just in the US in 2002, the disapproval ratings for the real estate agents were highest compared to any other service providers (Dabholkar and Overby, 2005).

With the increase in internet penetration and globalization, online marketing in real estate business has increasingly become a primary mode of reaching out to consumers. A study in the US concluded that 90% of consumers did online research before they bought their last home (RealTrends, 2013). Moreover, eighty-six per cent of Australians go online as their major tool to find their next property and nine out of 10 agents use RealEstate and Domain for the advertising (Tan, 2016). A similar trend is also observed in Pakistan where house-hunters are now embracing social media over traditional offline methods for finding their ideal home. Even the overseas Pakistanis are increasingly approaching real estate agents and brokers through social media tools (Asghar, 2015).

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Furthermore, the literature shows that websites can be evaluated and compared from a variety of perspectives to increase its efficiency (Delone and McLean, 2003, Joyce and Lin, 2004). One way to study these could be based on a customer satisfaction perspective i.e. whether the website has been built with customers' goals in mind (Chanaron, 2005). Alternatively, the evaluation could also be based the perspective of web designers and measure the factors that they considered to be important when designing or developing effective websites (Tan and Tung, 2003).

The two-phased research investigates customers' preferences and perception on integrating visualization tools such as immersive 3D models to online real estate marketplaces. At this phase, the online marketplaces selected as two the cases are evaluated across four attributes namely; content, design, organization, and user-friendliness as identified by researchers (Hasan and Abuelrub, 2011). This proposed framework of measurement attempts to strike a balance between contemporary market practices and multiple reference disciplines and focus on quantifiable features and indicators that at present found in successful websites.

METHODOLOGY

This research will be conducted in two main phases:(1) initial review of case websites based on criteria outlined by Hasan and Abuelrub (2011); (2) developing a survey for measuring users' perception. This paper focuses on evaluating a selected case platform by focusing on attributes revolving around customer perception of using online visualization techniques in real estate marketplaces.

In first phase, we developed a framework consisting of four major categories which were then subdivided into quantifiable variables as illustrated in Figure 1. The two selected websites were compared over these factors. The first phase of this study focuses on quantifying the features of both websites based on perception of expert customers in Australia. Each participant chosen was an experienced user and had at least 3 experiences of using the website(s) for renting/buying in the last three years.

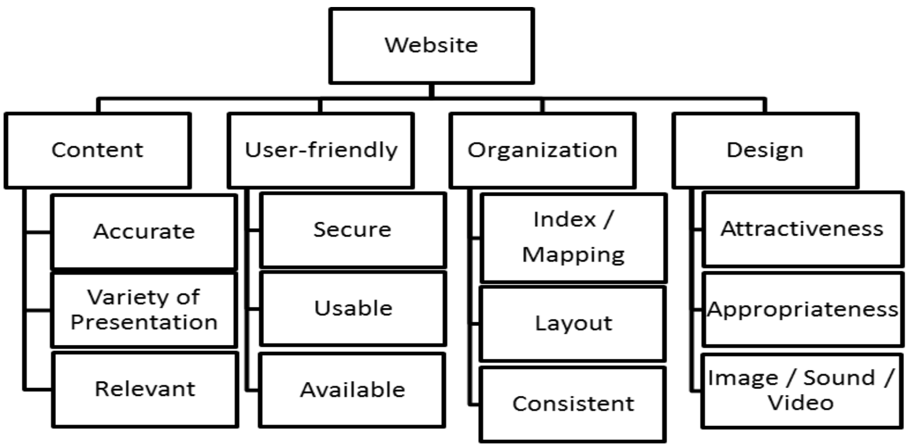

Figure 1 An initial framework for evaluating websites

According to Statstool (2016), a popular website statistic and SEO reporting portal, Zameen boasts a daily unique visitor count of over 7,900 and daily page views amounting to roughly 34,500 (StatsTool, 2016b). Similarly, it measures daily unique visitor count and daily page views for RealEstate to be around 44,700 and 233,700, respectively (StatsTool, 2016a). Table 2 shows case profiles for each website.

Table 2 Case Profile

Attributes	**Case 1: Zameen**	**Case 2: RealEstate**
Specific Property Information	Advertisements include seller details, images, property features, business & communication features (broadband/cable tv access), map, nearby places, finance calculator, trends, agent contact form, related properties.	Advertisements include seller details, general/outdoor features, images, floor plans & interactive tours, map, inspection/auction time, nearby schools, suburb profile & market data, email form to contact seller/agent, tools & calculator.
Service Category	Properties, forums, blogs, maps, trends, index	Buy, rent, invest, sold, share (links to partner site), new homes, retire, find agents, lifestyles, news, commercial (links to partner site)
Search Property Type	Houses, flats, portions, farm houses, plot files, agricultural, residential plots, commercial plots, industrial, plot forms	House, apartments & unit, townhouse, villa, land, acreage, rural, blocks of units, retirement livings

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Search Refinements	Search can be narrowed down based on location, price, area, number of bedrooms, financing options, agent type, and verification status.	Search can be narrowed down based on location, price, area, number of bedrooms, car spaces, indoor/outdoor features and eco-friendly.
Search Results Presenting	Results are displayed in form of list and can be sorted based on price, area and verification status.	Results are displayed in form of list, map or on a calendar. Sorting can be done based on price, date and suburb.

The study will be extended by conducting the survey in the second phase which is not covered in this paper. It is supposed to recruit customers and measure their perception in two selected countries. The designed questionnaire will include a total of twenty questions based on the Contents, User Friendliness, Organization and Design.

RESULTS OF CASE EVALUATION

A head to head comparison of Zameen and RealEstate was initially made to study the service offering of both the web portals. It was observed that each website provided similar information specific to property for each listing. Furthermore, while RealEstate provided a separate tab for detailed property floor plans, Zameen provided the basic floorplans as one of the images in the listing since Pakistani consumers may be less interested in technically detailed floor plans. Additionally, it was observed that Zameen was more comprehensive in service offering as it included information on commercial and industrial properties while RealEstate would link to partner sites like “RealCommercial” for Commercial Properties.

Interestingly, service offerings of both sites were organized in a different manner. Zameen focussed on different needs of a single user and organized services based on the needs. For example, a user could use “Property” page to search for any type of property, or go to “Blogs” tab for curated contents by the Zameen team. While RealEstate organized services based on individual needs of different consumer groups for example, a separate page dedicated to for property rentals ad separate for selling properties. Elements of localization were observed in both cases, such as the search refinement by RealEstate allowed users to narrow search based on indoor/outdoor features of the property. On the other hand, Zameen allowed users to narrow down search results by choosing only properties from trusted/verified real estate agents.

Next the two cases were analysed across four selected attributes namely Content, Organization, Design and User-friendliness. Important findings of the study are shown in Table 3.

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Table 3 Comparison of Zameen and RealEstate

Attribute	Case 1: Zameen	Case 2: RealEstate	Advantages of Visualization Technologies
Content	Mechanism to verify details of ad by website. Is costly and time consuming.	Only user details of advertisers are verified however content is not verified.	Automated verification process that compares the information listed with 3D Model
	Limited to English and "Urdu" Language.	Limited to English only.	Users can extract information from 3D model without much reading of the text
Design	Advertisements are cluttered all over the website with a prominent premium advertisement banner on the top of the website.	Less cluttered as considerably less advertisement which are featured at the middle or in the bottom of page.	Observing user behavioural patterns on a 3D model can allow target advertising allowing a more attractive and less cluttered website.
	The website uses less visuals to for a faster browsing.	Large banner images are used as being less graphic intensive is not a concern.	Images can be cut down and replaced by a single 3D model with option to scale the resolution to allow speedier browsing.
Organization	Details provided in each listing are highly variable .	Details provided in each listing vary to a lesser extent.	3D models will allow consistent information as the user can "see" the property.
	Basic search tools to filter the results to user's criteria.	Optimized search engine that allows user to refine the search to a much finer level.	Use of 3D model can cut down the search time and allow a speedier transaction.
User Friendly	No interactive features offered in design of website.	The website offers a VR solution but it is limited to static 2D pictures .	3D model may allow user to plan to move into the property as they can calculate cost of furnishing.

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Table 3 shows that both websites suffer from similar set of issues. These issues, particularly those related to the content can be resolved by incorporation of advanced visualization technologies such as using 3D model. This model is equipped with a pattern recognition program to identify user's buying behaviour based on previous local searching practices by other users. This is a smart 3D model which also can provide valuable quantitative data sets to the owner in an automated manner. The smart property visualisation system (SPVS) gives the possibility for interactive inspections which allow international users to visit their selected properties. At the same time, the potential buyers can estimate dimensions and volumes of the property for future carpeting, flooring and furnishing.

To support the findings of the case analysis, a group of 12 experienced users were interviewed and asked questions from four categories namely content, organization, design and user-friendliness.

The responses of the experts indicated that while the user opinion was largely positive on User-friendliness and Content attributes of the online marketplaces, their perception on Organization and Design quality was less so. Around a fifth of the participants were strongly disagreeing to disagreeing with the standard of information/content available on these websites. Moreover, the analysis also explored the relationships between the variables identified in Figure 1 and the user preference based on responses provided by the experienced users. Table 4 shows correlation between some key variables such as the clearly presented results and the reduced need to inspect the property physically. It is noteworthy to mention that the user's preference to use the website again was strongly correlated with the integration of 3D model in website to improve reliability. The participants' response to future use of website was also strongly positively correlated to the clarity of the search results.

Table 4 Correlation Coefficients for Key Variables

Variable		**Correlation Coefficient**
Search results presented clearly	Less need to inspect property	0.80
Easy to use	Less need to inspect property	0.84
Provides accurate information	Will recommend the website to others	0.96
Adding 3D Model will make information more reliable	I will use the website in future	0.90
I will use the website in future	Search results presented clearly	0.92

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Experts' feedback was also collected over the reliability of information available on their choice of real estate website. Only two participants were satisfied that current websites did not need any improvement, while the rest of them suggested use of new visual options. Half of participants also highlighted that real estates should provide higher level of details on their websites.

In addition, the participants suggested that by adding a 3D model the reliability of the website can be improved. This reinforces the idea that advanced visualization techniques such as a 3D model will be required to improve the current reliability issues faced by users. It may also stream line the transactions by reducing the need to physically inspect the properties. Therefore, the visualisation quality should be determined in next phase.

CONCLUSION

This paper addresses a clear gap in the literature of real estate marketing. The paper aims to investigate the customers' perceptions of using a web-based visualization technology for real estate business. The lack of reliability and consistency of property information available online means the constant need to inspect properties physically. This is an ongoing study including two phases: developing a framework based on a case study, and conducting a survey to measure customer perception on incorporating online visualization techniques. The paper presented the result of evaluating real estate marketing platforms as case studies in Pakistan and Australia. The case analysis of the two-leading online real estate marketplaces in Australia and Pakistan shows that each website offers similar array of features. The analysis also shows that the current platforms suffer from similar set of issues such as verification of property advertisements. These can be resolved by integration of visualization technologies. The analysis is supplemented by conducting interviews with experienced users to gauge customer perception and preference. The participants verified that the current web platforms should be revised using advanced visual options to develop the smart property visualisation system (SPVS). In addition, it is stressed that SPVS should provide high level of details on their websites. Additionally, the participants suggested that by adding a 3D model the reliability of the website can be improved. It was observed that clarity of search results and provision of a 3D model are some of the key factors influencing the user preference to use the website again. This reaffirms that users can overcome reliability issues and streamline transactions if advanced visualization techniques are integrated into the current online real estate marketplaces. Also, this study will be extended by conducting a survey on a larger set of consumers in Australia and in Pakistan and to evaluate customer perceptions on technology integration.

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VALUE MANAGEMENT IN ARCHITECTURAL EDUCATION: CASE PROJECTS ON RE-PURPOSNG HERITAGE SITES

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ABSTRACT

Architects are best positioned to embrace Value Management (VM) at early project stages. VM helps to maximise project outcomes not simply in terms of cost-benefit but in the larger picture and long-term vision. Project objective identification is the process of guiding design teams to achieve common goals and maximise project values through an ideation process. Five heritage sites are used to investigate value management uptake in a traditional design studio context. Findings show that VM assists on the value creation and value capture process maximizing project lifecycle outcomes. Although a structured technique, VM complements ideation and creative processes traditionally applied in design studios providing thus an evaluation framework for architects. VM was also seen as an effective technique to effectively engage with clients.

Keywords: Value management, Ideation, Creative Thinking, Design

INTRODUCTION

Project value generation is a key requirement to ensure project success (Grimsey and Lewis 2004). Value Management (VM) is a technique which can ensure project outcome success if well applied by combining its creative and evaluation process stages in the VM application, it supports stakeholders to establish a shared vision of the project and guiding the process requirements to deliver a design intent (Edwards 2013). Aranda-Mena (2016) discussed the need to increase business skills in architectural education and recommended a stronger uptake of management techniques by the architectural profession, both to better engage with clients including VM, stakeholder management and to improve internal business practices including stronger uptake of BIM and digital technologies (Aranda-Mena 2009) as systematic reflective practice (Shön 1983 and Walker 2002).

Lawson's seminal work on 'Cognitive Strategies in Architectural Design' (Lawson 1979), *'Design in Mind'* (Lawson 1980) and more recently

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‘Design Expertise’ (Lawson and Dorst 2009) looked at architects, their practices and business thinking and claimed that rational thinking does not inhibit creative thinking. On the other hand rational thinking is necessary to achieve project delivery (Gero and Kannengiesser 2006). The suggested approach is not mutual exclusion but to be holistic and inclusive of both inductive and deductive logic.

In order to demonstrate that structured management and business techniques applied in a traditional Master of Architecture design studio can indeed bring value to projects without compromising on ideation, design and creative outcomes, five architectural case projects are presented. Each project has a particular focus on repurposing heritage sites.

VALUE VERSUS COST

VM is a set of principles whose application is intended to maximise beneficial project outcomes not simply in terms of cost but in the *overall functional value of a project*. VM can be useful to architects and other construction professionals. It helps stakeholders to achieve three core outcomes: (1) establish a shared-clear vision of project requirements and outcomes; (2) identify clear objectives; and (3) guide teams to creatively achieve common goals and maximise project values (Grimsey 2010).

Project clients expect their architects and professional teams to deliver value beyond documentation, and bring *value* to their projects (Aranda-Mena 2016). Value and cost are often misunderstood and seen as synonymous. However, value is not improved if cost reduction impairs required functions. Indeed, spending more on a project may yield functional benefits that outweigh the additional expenditure.

VM in not solely about cutting costs but identifying and achieving project value through ensuring mutual understanding of the value being sought such as *project vision* including functional, aesthetic, cultural and other values manifested in the creative stage, and (b) *implementation* or how the value is to be achieved, in other words the objectives to be fulfilled through an effective process (Foster 2013).

As part of the briefing process, Lepak et.al (2001) identifies three priorities to satisfy client needs and thus, manage expectations:

Understanding the project priorities and business *objectives*;

Providing advice which assists client to gain *competitive advantage*;

Being *client oriented* rather than project focussed.

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Although a radical departure for architecture and design, there has been a level of increased acceptance of the importance of sound managerial and business techniques since the 2008 Global Financial Crisis (Heintz and Aranda-Mena 2012) and a shift in thinking with the end-users in mind, from exclusively project/design values to social/client values. Clients eventually have to validate the question of value for money (VfM) and its criteria; however they can also be short-sighted and look for short-term high-gain solutions that are not necessarily in the best long term public interest (Lepak 2007).

A common threat risk factor in projects is the lack of clear vision, clear objectives and adequate project definition, any of which can negatively affect project success. For major projects with high social or cultural impact, institutional clients would normally launch a competition or call for expression of interest (EOI) to which many architects respond without questioning the quality of the briefing documents (Volker 2010). For both public and private projects, briefing documents have been found to lack specificity about objectives; or be misleading or vague. VM could be an effective systematic approach to better (risk) manage a project by clarifying and confirming the brief at an early planning and conceptual design stage.

VM PROCEDURE

Edwards (2013) provides a framework for a VM workshop/process which originally (pre-2000s) might have been held over two to three full-days. Contemporary VM workshops are more likely to be undertaken as a series of short (half-day) interventions that each address different and specific issues. Ideally, each VM workshop structure might incorporate four initial phases each addressing different questions:

A. Information phase: What is it? What does it do? What does it cost? What is it worth (functional value)?

B. Speculation phase: What else would do the job?

C. Evaluation phase: How well does that work?

D. Development phase: How much will that cost?

The workshop must be followed by presentation of findings, client decision-making and implementation if VM is to be effective. During the information phase, the client and the team are clarifying objectives, ie. What is the project context - what is the client trying to achieve with this project? The latter will incorporate "***To***..." statements:

1. What is it? E.g. a gallery in a cultural precinct intended ***to*** *significantly increase the cultural and artistic awareness of the public* (but note that if this is the primary objective, a new gallery may not be the best solution!)

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2. What does it do? Traditional VM implemented to explore alternative component design solutions uses a verb/noun technique to establish required function, e.g. *transmit* (verb) and *light* (noun) is the required function for a window.

3. What does it cost e.g. a monetary value to represent the cost of the component in the finished project (including full life-cycle cost assessment if necessary).

4. What is it worth? E.g. here is where VfM assessment sits. Wherever possible VfM is expressed as a cost per unit of delivered function or as a unit of delivered function per $1 of cost.

In the speculative phase alternative ideas are canvassed, *but the practicality and cost of these are not discussed until the evaluation phase*. The VM evaluation phase should pass each alternative through three initial filters including Level 1 Filters: *Objectives* (does this alternative satisfy the objectives?), Level 2 Filters: *Functional Performance* (does this alternative deliver better, or the same, performance as the original solution?), Level 3 Filters: *Unique implementation constraints* (what would prevent the adoption of this alternative on this project?)

The development phase of VM is limited to the cost implications of the few best alternatives emerging from the evaluation phase. The workshop investigates the cost of each idea (again including life-cycle costs if necessary) as far as possible given the constraints of workshop time and access to suitable cost information. Besides cost comparison, the intention here is to minimise uncertainty in the ensuing client decision-making. The VM process can now be demonstrated in the context of architectural education, using examples from post-graduate design studios run by the author.

CASE PROJECTS

Five architecture and planning projects are described with the intent of extracting relevant attributes and lessons of the value management exercise. The VM workshops were incorporated into design studios that took place in Milano and Mantova (Italy) as part of Master's degree programs in architecture. The real-life case projects are located in Melbourne, Milano and Mantova and the studios were held between 2014 and 2017.

4.1. National Gallery of Victoria: Gallery of Aboriginal Arts and Culture

Melbourne's Central Business District has seen much transformation over recent years. Over 30 years a large part of the old city centre has become residential through the re-purposing of old office blocks and other commercial buildings. The success of this is due to a steering group set up to interpret regulations applicable to converting offices and warehouses into residential apartments. Currently, with the explosion of

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high-rise flat development in Melbourne CBD, and similar residential development in the adjoining former docklands area, the focus is being re-directed towards the arts, culture and conservation of heritage and listed buildings.

The National Gallery of Victoria is of historical importance as the first substantial civic building constructed in Victoria (Australia) in the half century following the First World War. It was also the first Art Gallery to be constructed in Australia after the Second World War. It set new principles for exhibition layout, and art conservation and symbolised the future in the arts and public architecture. The site developed into the major hub for the arts in Victoria and presented Melbourne with a significant visual icon. In 1959 Roy Grounds, Frederick Romberg and Robin Boyd were appointed architects to design a new NGV on St Kilda Road. In 2004 the gallery was enlarged and completely redesigned by Mario Bellini with Metier3 architects leaving the exterior of the building untouched.

The NGV is currently speculating on new galleries and spaces to display Australian Aboriginal Art and Culture. The chosen site location for the VM workshop is by the north banks of the Yarra river in what is know as the Birrarung Marr park. A full project briefing on the proposed new Aboriginal Art Gallery and Cultural Centre for the NGV was presented including design-brief review and project proposal development. At the early project stages, an in-depth study of the NGV as an institutional client was conducted, including an skype presentation by the NGV Capital works and operations manager. The resulting project submissions comprises an arts precinct with gallery and open exhibition spaces and strategic economic and lifecycle considerations built into the proposal. A risk evaluation framework included management implications for three dominant axes: the project, the process/time and the people involved.

In the design studios, teams of four architects analysed and compared the proposals on their response to the primary, secondary and desirable objectives set through the VM workshop. Sketches, drawings and 3D models including Building Information Modelling (BIM) techniques merged in order to explore schematic design proposals and put some ideas to the test. Finally, a life-cycle and economic appraisal was presented and evaluated. To clarify and redefine the project, a two-stage Value Management workshop was conducted.

The VM proved to be effective in clarifying and identifying project possibilities and cost implications. Finally, the stakeholder circle methodology (Bourne and Walker 2008) was introduced to establish a clear understanding of stakeholder interactions and governance structures. By applying the technique teams were able to identify risks and difficulties in terms of project deliverables and potential people/organisational issues. The VM technique would better prepare the project team to creating project value as to managing risk.

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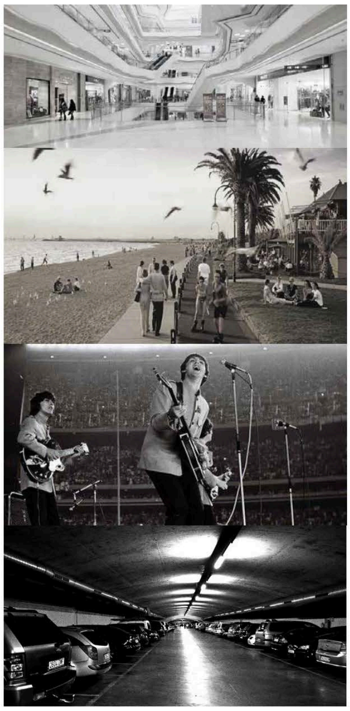
4.2. St Kilda Triangle Urban Intervention in Melbourne

Studio project brief: St Kilda is a close suburb of Melbourne. Melbourne's increased growth and living density is expected to double facilities and users' demand by 2020 with a forecast population of 8 million inhabitants. This growth will necessitate providing and expanding amenities around the heart of St Kilda, which will include improving tenants, shoppers and tourists an enticing experience over shortsighted provisions of retail, living and commercial space. The proposed plan is to extend the coastal leisure area and bring the Luna Entertainment Park and Palais Theatre facilities up to 21st century standards. The development needs to integrate with potential public transport (ie. trams, buses, etc.). The St Kilda "Triangle" vision provides clear definition of the urban space involved over 20,000m^2 of Crown land with a 99-year private lease.

This studio process involved dimensioning all the solutions appropriate in the analysis phase. Since the solution is mainly open spaces we preferred using this dimensioning system rather than a volumetric analysis. We also needed a generic concept sketches to develop rough ideas of how these surfaces will translate from activities into spaces either in surface area or volume. Table 1 reflects the analysis.

Table 1. Functions, activities and space analysis

1-Commerical	1, selling/shopping 2, having meal 3, storing 4, accessing	Large - span space 5000 m2
2- Sporting & Leisure	1, playing skateboard 2, cycling 3, running 4, leisure	Outdoor space 7000 m2
3- Performing	1, Festival 2, Acting 3, Watching	Terraced space 800 m2
4- Parking	1,accessing 2,parking	Underground space 3000 m2



4.3. Heritage Gold-Fields, Country Victoria, Australia

Studio project brief: The VM workshop should incentivise this regional area of Victoria. The studio project was set around the same thematic initiative involving architecture, heritage and tourism values, thus exploring the potential to increase economic possibilities, particularly around the former gold mining areas in the cities of Bendigo and Ballarat and the town of Castlemaine, with the aim of increasing employment by attracting and retaining tourists for longer than the average 1-day visit. The VM workshop was instrumental for elaborating urbane scenarios and value capture possibilities and staging them with an implementation plan.

Four distinct locations were identified in order to attract tourists and activate the local economy. Infrastructure development and building restoration was expected to eventuate without destroying the built and intangible heritage (such as arts events, framer market and other traditions) of the region. The value of running the VM workshop is that it not only provides opportunites for creative thinking and ideation but also provides an structured framework to systematically assess the emerging scenarios as a form of early feasibility and risk study. Early VM output is shown in Figures 1 and 2.

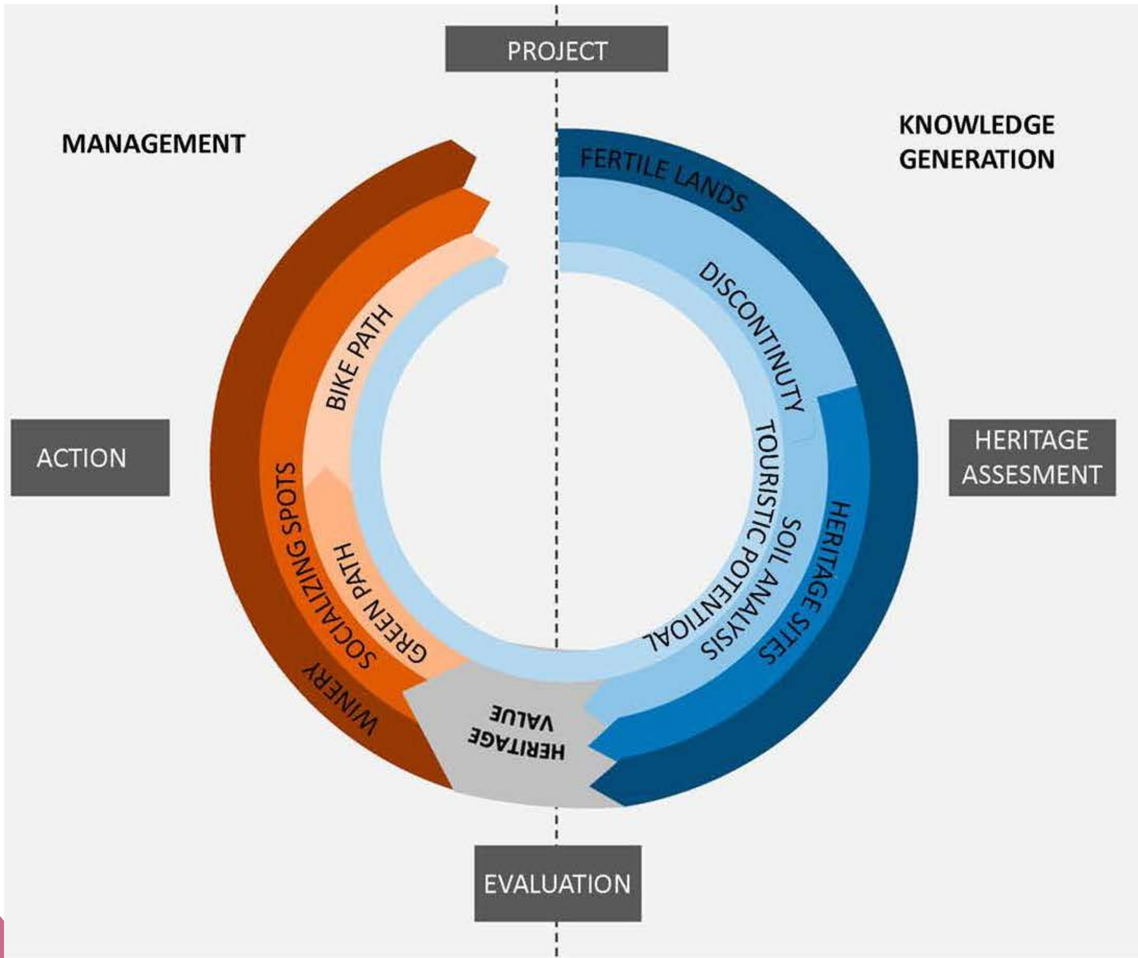


Figure 1: Idea evaluation and implementation

The Victorian gold-fields example shows possible scenarios emerging from the early stages of the VM workshop from which a series activities (verbs) and buildings or locations (nouns) emerged. The visualization stage is a step which architects are probably best-fitted to deliver. In other words, this is a stage in which the vision and objectives are translated into drawings and exploratory models. At this stage it is important to continue

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working with potential development scenarios and to leave judgmental evaluation until later. The framework eventually calls for rationalization.

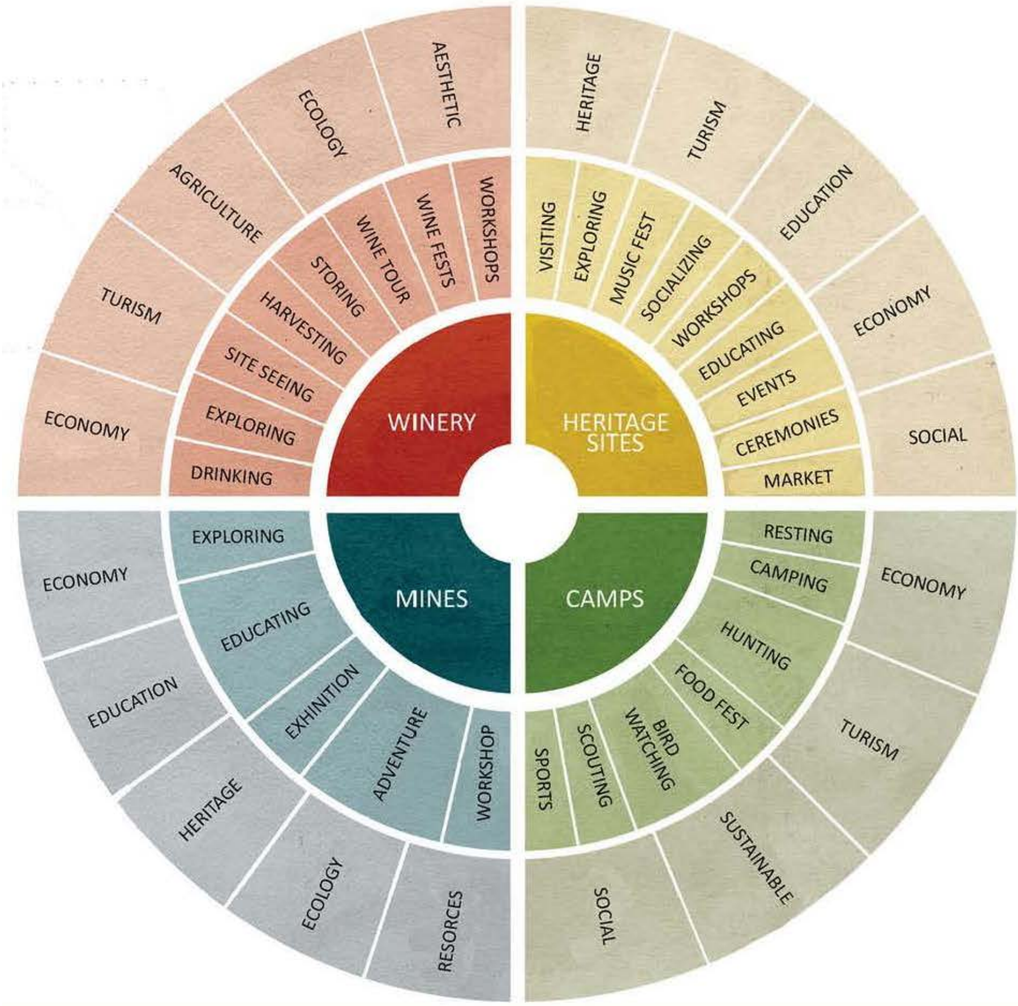

Figure 2. Value generation example diagram

4.4 Lambrate District in Milano

Studio project brief: This is a social approach to urban regeneration in Milano, Lambrate. The project investigates a method for transforming a ghetto/derelict zone into a sustainable living community. As part of the experience of being in Italy, the author agreed to supervise a Master Thesis on this project that aims at developing an urban regeneration proposal for the Lambrate suburb zone, north of Milano. Lambrate originated as a Roman vicus as they conquered the area in 222BC and developed for agriculture and navigation along the rivers Po and Lambro. After WWII, the Innocenti machine factory began production of the famous Labretta motorcycle in Lambrate. The factory closed in 1996, six years after a takeover by Fiat, and the factory facilities have since been abandoned. The site had become derelict and a meeting point for homeless people. The thesis proposal looks at repurposing the abandoned facilities and presenting value generation scheme in which microbusiness and start-ups could take place. The scheme seeks sponsorship and

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financing from a number of private, public and NGOs. The urban design intervention also caters for adjacent surroundings, providing leisure spaces and green areas including urban furnishing, lighting and signage. Measures to increasing safety and security concerns emerged through the VM exercise which became primary objectives on the final evaluation of the project proposal (Kuzilenkova 2016).

4.5 Campus upgrade in Mantova, Italy

Studio project brief: In 2016, Mantua (or Mantova) became the Italian Capital of Culture. In 2007, Mantua's City Centre and the nearby township of Sabbioneta became UNESCO World Heritage sites. Mantua is well known to architects as it hosts famous renascence architecture by Leon Battista Alberti and Giulio Romano such as the St Andrea Cathedral and Palazzo Te from the 15th Century. All buildings in Mantua are heavily protected and this presents difficulties with repurposing a site such as the University campus ie. in the fashion of a university campus such as TU Delft in The Netherlands (see Den Heijer 2011).

Mantova campus is part of the Politecnico di Milano. The VM workshop scope was limited to the School of Architecture, which is hosted in a five-centuries old hospital. The VM process was instrumental in re-thinking the University campus, its role and facilities as experienced by students, researchers and academic staff. The vision was to *bring a new life to it* by increasing the standards of a new facility and academic campus life, yet in an ancient millennia setting with much tension between past and future.

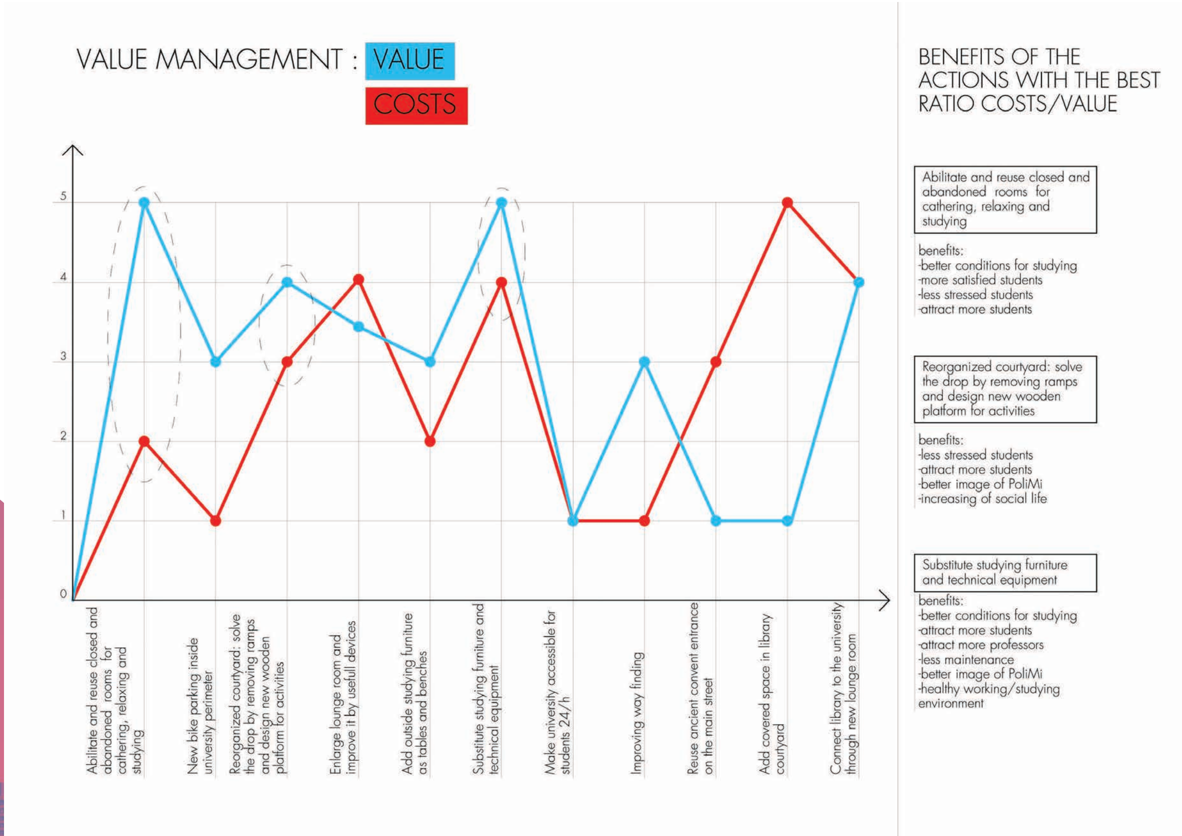

Figure 3. Value creation: cost-benefit analysis

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As seen in the above Figure 3 issues to solve were identified during the workshop included: general access (including disability access); study areas and workshop rooms; computer facilities and audio-visuals; green and leisure areas; utilisation of unused or lost spaces such as corridors; improved way-finding and horizontal connections; bicycle-sharing bays; and sport facilities.

The emerging gap analysis compared envisioned *added-value* versus *cost*. This first stage of the project is highly creative and it is important to look at the right graphical and representation methods to visualize emerging themes and ideas. This VM will continue in 2018 and will form the basis for a report on briefing techniques for educational and research facilities.

DISCUSSION AND CONCLUSIONS

Through the five case projects VM has been shown to be a method and procedure that responds well to architectural briefs. The experience of running VM workshops, with clients and graduated architects in Italy, as part of the educational curricula, has also shown to be culturally adaptable.

An observation from the studio experience is that incorporating VM improves the ability of architects to perform well under the uncertainty of early project stages when the project program or brief is still forming and problems are not well identified nor defined, thus speculative thinking becomes highly valuable with the potential of generating *visionary ideas*.

An aim for the VM was to maximise the ideation and creation process yet, to provide and evaluation framework to rationalise and evaluate possible outcomes in order to identify those which provide better VfM for the client. In this way the Value Management process aimed at formally establishing and prioritising project objectives. Judgement of alternative options was left to a later stage, at the initial stages the VM workshop appeared to apply *'inductive logic'* at all times which eventuated in *outside-the-box* outcomes. Introspection, critical, reflective and deductive thinking followed.

Finally, it is argued that the interrelation of design-thinking and rational thinking processes are complementary, demonstrating that value management should not be seen as overshadowing the ideation, creative and design processes but as a framework to support them. The tools and techniques from business and management disciplines, including VM should be seen as complementing disciplinary competency and not the other way around. The author advocates for the inclusion of VM in the curricula for architectural education.

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BIM INTEGRATION IN ARCHITECTURE STUDIOS: THE G-LAB MILANO

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ABSTRACT

Does Building Information Modeling (BIM) hinder creativity and design thinking? Can BIM be embedded into Master architecture studios at early project conceptual stages? These two questions were addressed through experiences of running architectural graduate studios at Politecnico di Milano, Italy with an embedded BIM component. This paper is reflective in nature and discussion is based upon five years of anecdotal experience, thus providing in-depth discussion before diving into a quantitative follow-up study. A single case study is used to elaborate on the interactions of a manual design (including CAD) versus BIM iterations. The findings show that BIM does not hinder creativity but promotes a more rigorous thought process as ideas are demonstrated and tested. BIM is rapidly moving as a cloud-based application opening opportunities for *iterative connected design* and this is expected close the gap between creative conceptualisation and rational project stages, significantly if not fully. An open discussions on BIM implementation in architecture education is presented including the integration of BIM into the teaching curricula.

Keywords:

Architecture, Creativity, Ideation, Rational Feedback, Cloud-BIM

A BIM NEW WORLD

This paper is a follow up from a presentation at the 2016 CIB-W78 conference that discussed the implications of emerging information and communication technologies on architectural education and stated that *"the practice of architecture as we know it today will be drastically different as a consequence of Building Information Modeling (BIM)*, and the question addressed then was: *How can architectural education better prepare future architects?"* (Aranda-Mena, 2016). It dealt with emerging architecture practice modes as a consequence of technological, managerial and contractual advancements. This paper deals with personal reflection on BIM and design interactions in architecture. Is BIM to

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support the expected creative and visionary built forms often expected from architects? This paper uses hands-on case study to probe the question and elaborate on the topic in anticipation to a follow-up quantitative paper.

Design methods and processes are continuing to change at a rapid pace, especially with Cloud-based BIM advancements in which users log-into shared workspaces via a web-browser. The question is no longer 'to *BIM or not to BIM'* but more about the best *modus operandi* to adopt, such as online Cloud integration in which a cultural shift in architecture practice is required (Aranda-Mena 2016). Advanced and newly-emerging tools and technologies are available for designers and construction professionals including mobile computing, as tablets and even smart phones are become increasingly used in industry (Crolla and Fingrut 2016). Translating these developments into tertiary education curricula becomes a problem if the rate of technological change outstrips the procedural capacity and cultural change of the educational institution and the target discipline itself.

Heintz and Aranda-Mena (2012) investigated emerging practice models in architecture. This followed the 2008 Global Financial Crisis, which forced architects to re-think their career strategies and business mechanisms. In order to survive, architects and other building professionals not only need to be more resourceful by adopting smarter marketing and technological strategies but also acquire internal business competencies in order to efficiently deliver projects to stakeholders and satisfy clients' and end-user demands. Bjerk Ingels from BIG Architecture talks about this in his company's approach to design (Ingels and Andrachuk 2015). *Design differentiation* alone is not enough for architects to succeed in business. More tangible differentiation, such as technical, managerial and business capabilities is needed, and skills in these areas should be acquired during university education, and not left for graduates to learn "on-the-job" (Heintz and Aranda-Mena 2016).

Higher-education property (and cognate discipline) programs must closely follow the changing dynamics of the professions, tapping into student satisfaction and expectations, and preparing them for work and life (Robson et. al 2017). Traditional degrees, such as architecture, are expected to change dramatically in line with other established professions as we know them today (Schwab 2016), driven by an emerging '*services client-focused economy'*, and are expected to flourish during a 4th revolution that will witness the advent of new economic arrangements akin to the *'collaborative social commons'* predicted by Rifkin (2014). Emerging modes of practice such as the '*gig-economy'* are already being manifested, with services on-demand sourced from a "cloud pull", such as UBER taxis, AirB'n'B accommodation and similar innovations. Employment will continue to shift towards a more casual basis. This is already a common form of practice in the video-gaming development sector, and

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higher-education is not immune to the changing rules of the game (Rifkin 2014). The mode, content and currency of higher- education and roles of educators and academics are rapidly changing.

Fien and Winfree (2012) argue that the higher-education sector across the building professions, including architecture, has been slow in tailoring technological uptake in their curricula, even when demands from employers are clear on what is needed in terms of expected technical competencies. The integration of practice and educational curricula is often a challenging one. Work Integrated Learning (WIL) programs in Australia are a response, but fall short in supporting BIM adoption in architecture (Patrick et.al 2008). Educational books dealing with topics such as *"What an architecture student should know"* (e.g. Krupinska, 2014) are now expected to include chapters such as *"BIM for architects", "collaborative practice modes"* or *"integrated project development"*. As yet, such books rarely do so, and much of the BIM adoption has been left to project managers (Holzer 2016a). For instance, Fien and Winfree (2014) identified the range of BIM uses within the industry as a modeling tool, information tool, communication tool and a management tool, but with no mention of BIM as a *design tool.* The next section discusses the possible reasons for the tension between *design* and *rational* thinking and thus puts forward the argument that to bring BIM values in architecture it should straddle both cognitive processes.

BIM-COGNITION: RATIONAL VERSUS DESIGN THINKING

BIM is expected to expand from a project documentation domain into a design domain in which creative and design thinking is applied. BIM has matured into a robust technological platform to deliver projects efficiently (Eastman 2009). Less discussion has taken place around its merits to enhance ideation, creative and design thinking. BIM is often perceived as restrictive during the early schematic stages rather than being an enabling tool.

Design thinking is a problem solving process and the design studio is a critical venue for design students as they develop creative skills, aesthetic appreciation and other cognitive skills in a shared learning space (Michalatos 2016). The question is whether BIM should be seen as something inclusive of the design domain or as a step in the project process such as implementation, documentation and project appraisal? With a focus on design learning this section discusses the tension between the *creative design space* and *the rational thought process* needed to deliver high quality architectural projects. A continuum of *design-rational thinking* as an iterative process is expected to bring true BIM value to projects.

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BIM applications are increasingly providing free-form commands such as *'loft'* in which shapes can be free-formed breaking away from the *'boxy'* style commonly seen in the early Revit models. BIM is often misunderstood as a single 3D software application such as RHINO. As a technology platform BIM is more like a 'toolkit' or digital ecosystem that makes use of 3D modeling software along with other analytical tools to simulate building outcomes, such as environmentally-sustainable design (ESD), construction, building-user operations and life-cycle behavior; all flowing from the conceptual design proposal.

BIM enables postgraduate studio participants to integrate their designs more effectively, thus generating information that can be used to make decisions and improve the processes of delivering a building (Holzer 2016a). BIM methods and technologies are increasingly being adopted by industry practitioners, which suggests they are well-informed of the advantages associated with BIM in project decision-making. Other clear commercial drivers, such as automatic generation of shop drawings (including built-in quality assurance) have provided enough *business incentives* for BIM adoption (Aranda-Mena et.al 2009). Further, *interoperability* for model data exchange is now a common practice (Aranda-Mena & Wakefield 2006). BIM adoption in practice has continued to increase and it is well documented in a McGraw Hill (2015) report. What is needed is an evolutionary approach to its incorporation into tertiary education. The BIM uptake model proposed here is an evolutionary/empathetic approach (with students and academics) rather than a disruptive one.

CASE STUDY: THE G-LAB MILANO

"The G-Lab" is the unofficial name given to the author's architecture and design studios in Italy at Politecnico di Milano (Mantova and Milano) and at RMIT University in Australia, Singapore and Hong-Kong, in postgraduate coursework programs. The "G-LAB MILANO" studio is part of the Master of Architecture and Design. For the case study described here, a teaching team of two architects, a structural designer and two tutors delivered this particular studio to forty graduate students. A professional client from an international fashion label company acted as an industry client and provided a design brief for a commercial retail space. Three of their current sites, across three continents, were provided and student could pick any of the sites.

The pedagogic aim of the studio is to engage with two cognitive processes, Design Thinking and BIM thinking. The expected skills from graduates include both ability to think creatively and ability to document and deliver projects. The latter expectation is clearly beyond the technical know-how of BIM technical competencies as a studio reality, but the cognitive ability to apply BIM skills into the design-thinking realm is well

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simulated and the outcomes presented as "virtual" reality. The Milano studio demonstrates the inherent value of applying BIM tools at the outset of important projects, not always in terms of scale but also by the project complexity.

Procedure: The following sub-section describes *qualitative* reflections about the studio. The discussion is presented anecdotally drawing on 'reflective practice' method (Schön 1983 and Donald et.al 1996) of a single studio. The *quantitative* study comparing student experience over 5 year period will be presented in a follow-up paper. This qualitative, exploratory stage reflects upon the *what?* and in some cases the *why?* discourse of BIM uptake rather than the *how?* It provides insights into the process from an experiential viewpoint rather than a detailed factual account. Strategic and tactical outcomes are expected to emerge, bringing out some of the tacit knowledge embedded into the process.

Forty graduate students undertaking the Master of Architecture at Politecnico di Milano were expected to submit individually an integrated design proposal for a retail commercial space including conceptual/ schematic design, project documentation and appraisal stages, over one academic semester. Panel "crits" and progress reviews took place on a weekly basis. Nine BIM software applications were made available to students as the *'BIM Toolkit'*. Traditional 3D AutoCAD was allowed in the studio, but could not be labeled as BIM, as the American Institute of Architects notes: *"BIM is much more than 3D rendering or transferring electronic versions of paper documents. By implementing BIM risk is reduced, design intent is maintained, quality control is streamlined, communication is clearer, and higher analytic tools are more accessible"* (AIA, 2005 in Aranda-Mena et.al 2009).

The BIM toolkit comprises nine software applications commonly utilised in *the G-Lab*. Each application is commercially available and well known in the Architecture, Engineering and Construction (AEC) industries. Some are open-source and freely available. The BIM Toolkit includes: Autodesk Formit, Revit and Navisworks; SketchUp Pro; Rhinoceros (aka Rhino); ArchiCAD; Sefaira; and parametric tools such as Grasshopper and Dynamo. Each BIM tool application is presented and introduced to students in the context of a built architectural project such as the commercial retail space project used in this case study.

Following morning lectures, a studio discussion takes place on the value of BIM in architecture, in particular through the design process and the impact of project evaluation for building life-cycle consideration. BIM attributes and impediments are discussed with the class including on the perceived value they add to the project. After the discussion, a hands-on demonstration is carried out.

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The lecture, discussion, and demonstration in studio style is perceived effective as it tackles questions at three various levels including: 1. The lecture questioning stage: the *"why?"* eg. *'why will BIM bring value to the process?'*, 2. the demonstration stage: the *"what?"* eg. *'what can this software do for me?'* and the hands-on studio or workshop with *"the how?"* e.g. steps 1 to *n* on how to use and apply the software. This process is repeated each time a new BIM application is introduced to the class.

The design studio combines aspects of hand and tablet sketching, also 2D detail drafting in AutoCAD and ArchiCAD (as 2D drafting) and 3D modeling, all happening concurrently. The interesting aspect of this approach it that students learn the pros and cons of various approaches. The studio aims to be resourceful rather than prescriptive on the use of BIM tools and representational methods. However, the final output has to comply with standard project submission requirements, standard layouts and conventional blueprints ie. extracted from the BIM models. Thus it is important to know which are the best tools at particular steps in the process ie. for creative thinking, for spatial representation or for technical specification and construction detailing. The important aspect of the studio is for students to experience digital tools and methods, and become aware of their pros and cons, so as to support their design intent, aiming to align innovative design outcomes with efficient processes.

Results for the reflective process of this paper will take the form of a *Qualitative Discussion* highlighting the attributes of the BIM Toolkit in practice and providing insights into the process. A follow up, quantitative paper will be in a confirmatory format with student feedback data for 5 consecutive years of running the G-Lab. Figure 1 indicates the way in which the outcomes from the BIM Toolkit, including nine (9) applications and nine (9) emerging *qualitative* attributes describing the applications, can be mapped. The BIM applications and attributes are manually placed into four quadrants and relationships established across each application in relation to the 9 axes indicating *bi-polar attributes* with contrasting descriptions such as free-costly, design-parametric.

Each bi-polar axis denotes the comparison (and contrast) across the 9 BIM applications. The "triads method" is applied in which groups of three elements are randomly selected to create the attributes. Such triad comparisons require the author (as observer) to reflect and to consider three BIM applications randomly selected each time. So if pulling three BIM applications together, a point of difference has to be established between two and a third one. For instance, applications *a, b* and *c* are presented for reflection, then applications *a* and *c* are identified as *'free'* whereas *b* is identified as *'costly'*. The process is iterative and forces the researcher to come up with a set of bipolar constructs, and not always with the expected opposite comparison *iPAD Tablet - browser*. The technique is known as *element triad elicitation* within the "Repertory Grid"

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research domain (Fransella et.al 1977). Figure 1 also shows the "Qualitative Cluster Dashboard" containing the 9 BIM Toolkit applications and the 9 emerging bi-polar constructs.

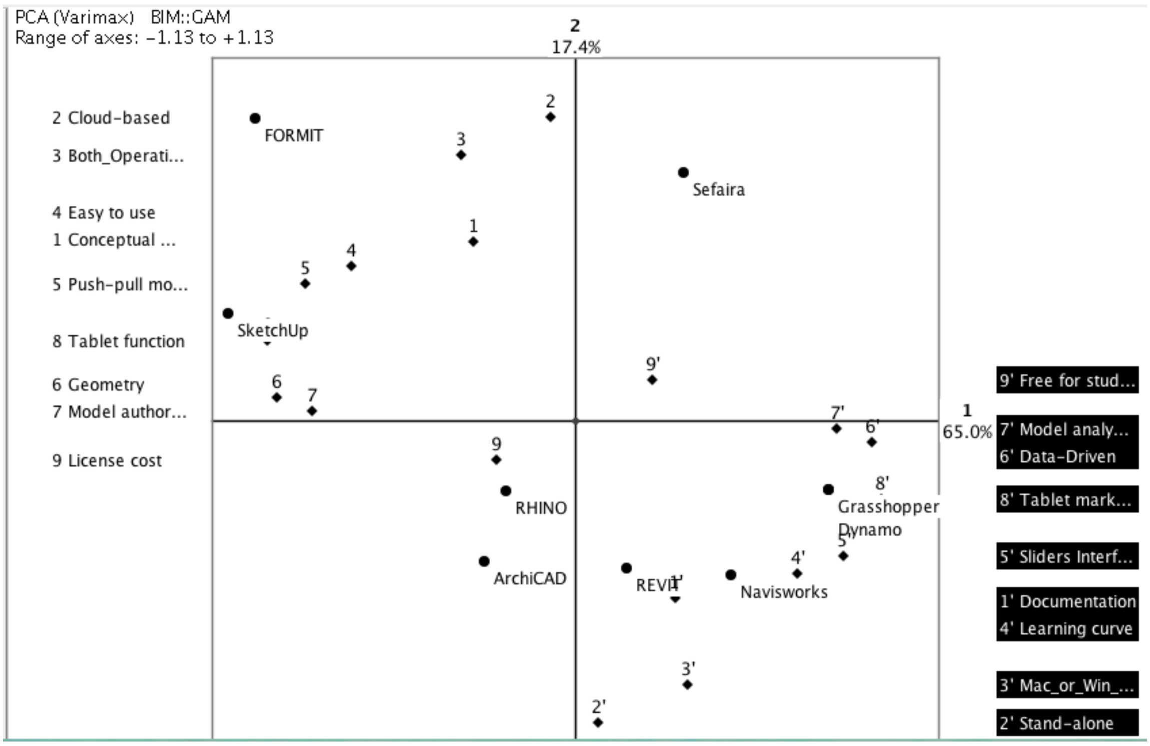

Figure 1: Qualitative Cluster Dashboard of elements and constructs

Figure 1 thus presents a picture that can be used to further discuss and speculate on the emergence of the attributes and their relationships with the 9 BIM Toolkit applications. The following discussion aims at creating insights grouped in four emerging clusters, in terms of what each cluster might be telling educators on the relationships between BIM use and design thinking. These clusters include: (1) Soft-landing; (2) BIM Authoring; (3) Parametric Design; (4) Cloud-BIM including aspects of on-line collaboration and discussions around generative design.

Cluster 1: BIM Soft-landing refers to BIM applications at the entry level. No previous CAD skills are required. This cluster includes tools that are user-friendly to operate and have rich visual interface. Using these applications, students can rapidly begin to develop building mass and massing studies including site analyses and shading studies. SketchUp and Formit are two tools well placed in this category, both intuitive to use and providing a 3D experience. SketchUP has been a popular tool for over a decade, and more recently Formit has emerged as Autodesk's response to it (including the *push-pull* command, which made SketchUp famous). SketchUp is still free (although not obviously so); this is from its days as part of Google, and has continued being so with Trimble. Stand-alone software installation is required.

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Formit, on the other hand, operates via a web browser and on iPAD and Android tablets via a browser or by installing the app. Formit can also be locally installed as a stand-alone application and runs in MS Windows operating system. Students can apply for a three-year Pro license which allows them to work on line and connect on the cloud. The Pro version allows design students to collaborate by joining sessions via a web link or by invitations using a unique ID. The Pro version also runs energy simulation tests. Formit has great connectivity with Dynamo BIM application for *parametric design*.

Compared with other BIM applications, the best aspect of Formit is that it is free and does not require software installation, making it the simplest BIM tool application to use. For educators, it is a handy tool to learn (and have a free Pro account) as it helps to teach basic 3D modeling to demonstrate the value of BIM during the early conceptual stages. On the downside, FORMIT is a risky tool to use as work can be lost if the Internet connection is faulty, especially if working on the browser or with a tablet. The stand-alone MS Windows version is more robust but not as stable as other stand-alone BIM entry applications such as SketchUp Pro or RHINO.

SketchUp Pro is still more popular than Formit especially in small design firms such as architecture, interior design or cabinetmaking companies. Due its widespread uptake it enjoys the support of many 3rd party add-on developers, thus providing a wide range of analytical applications for tasks such as quantity take-off and estimating environmental sustainable design ESD (eg. IES *Virtual Toolkit*) which is much used in practice and research. More recently, Sefaira ESD connectivity with SketchUp Pro is providing a user-friendly interface popular with architects. This brings more value at early project stages by providing a powerful energy assessment tool, assisting with project design decision-making at the early conceptual stages. Such decisions enable designers to improve their sustainable design responses, including an expected building cost and performance factor built into an array of project qualities. The case of Sefaira will be discussed in Cluster 3.

The Soft-landing cluster includes attributes 1 to 9 (listed on the top-left side of Figure 1) that clearly indicate and launch-pad into the BIM world with tools that are accessible, easy to learn, user friendly and also available online via tablets or web browsers. Soft-landing is the space where BIM can attract new users.

Cluster 2: BIM Authoring refers to software applications that are for creating geometric content such as object libraries, material families or complete project documentation. Authoring BIM software tools such as Rhino, Revit and ArchiCAD are well known industry applications to create geometry and document project content from a door-handle to a complete airport or hospital facility. "BIM authoring" tools and BIM are often mistaken terms which are not interchangeable. A full BIM

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encompasses both authoring and parametric analytical plug-ins. Students find RHINO and ArchiCAD more accessible to use at early project stages. Rhino has enjoyed the popularity created by Zaha Hadid Architects, especially with the Grasshopper open source parametric modeler (Block 2009). ArchiCAD is a mature BIM authoring application that is rapidly losing market share against the Revit dominance. Recent versions of Revit include plug-in connectivity with Formit and Dynamo which brings more flexibility on design shapes at early project stages. Although Revit is the current passport to landing a job in industry, similar to how knowing AutoCAD was in the 1990s, Revit is seen as restrictive to design thinking and more as a project documentation BIM application. Thus perceptions are rapidly changing.

Figure 1 places the BIM authoring tools in the two lower quadrants. RHINO and ArchiCAD are perceived as strong design and conceptual tools making Revit different. This is only a perception, as Revit is moving towards the left quadrant in Figure 1. Until now Revit has been seen predominantly as a documentation tool, but with full FORMIT and Dynamo integration it now can create flexible free forms at early conceptual stages making it also more intuitive to operate.

Cluster 3: Parametric/analytical BIM refers to the capability of designing with numbers or values typically seen in the form of "boxes and virtual wires" or "sliders". Parametric modeling relies on a visual programming for Rhino using Grasshopper or for Revit using Dynamo. Both, Grasshopper and Dynamo are free open source applications. Parametric engines can drive computational 3D geometric design. Grasshopper or Python is the visual scripting at the core of parametric modeling, which underpins commands.

On the other hand, analytical BIM tools are similar in operation and interface, but no programming is required. They are generally an add-on for BIM authoring tool such as Sefaira with Revit for ESD, CostX with Reivt for cost estimating, VICO with ArchiCAD for construction scheduling and site programming or cases such as Navisworks which are standalone applications. All good examples of analytical BIM much used in AEC.

Examples such as Sefaira are evolving into a BIM-cloud operability via web browser which is useful for project reviews or when engaging with clients. The application geared towards a social collaborative application, thus the online and user-friendly interface, also *cross-platform connectivity* ie. Soft-landing or BIM authoring tools.

To sum up, this cluster is distinctive and highly likable due their integration to popular BIM authoring or soft-landing applications (such as Rhino, SketchUp, ArchiCAD and Revit). In the case of the BIM Parametric/analyitical cluster students get to test ideas and visualise outcomes such energy savings due to design considerations or strategies

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for their own projects. This is a space for iterative design in which the creative-rational cognitive process is put to the test.

Cluster 4: Cloud-BIM relates to the increasing opportunity for teams of architects to log-in online to their projects and to work on them online. Possibly the most advanced example of this form of collaboration is that of producing the Boeing 777 "Dreamliner", in which virtual teams could log-into a virtual shared workspace and contribute by interacting with their tasks at hand (Yenne, 2002). Cloud-BIM is a reality in the aerospace, industrial design and manufacturing industries. It will increasingly be the space for the AEC industry and the area where architects and architecture could regain a leading position in the industry.

For the future, *generative computational design* will mimic nature's evolutionary approach to design. Designers input design goals and the relevant software can convert numerical figures into geometry, products or building shapes. The future designer will be more of a "curator" rather than making all the decisions *ad hoc* or reverting to manual drawing. The emerging technologies use algorithms to generate multiple options of a design solution and pointing to the best. Architects and designers will enter sets of parameters and then choose best outcomes from the options generated by the software.

The four clusters in combination indicate emerging trends of BIM learning and uptake in architecture practice and education including reflections on 'the creative-rational' cognitive process. The BIM toolkit and the emerging nine bi-polar attributes and four clusters are not exhaustive but do provide a launching pad for reflection and discussion.

CONCLUSION

The G-LAB Design Studio at Politecnico di Milano makes use of BIM to develop creative and documentation competencies in architectural education. Maintaining a balance between the arts and humanities, and the technological competencies expected from young graduates, is important. Generic professional competencies are important to a university degree followed by employment. Other skills characteristic in the architecture domain such as: (1) conceptual design (2) spatial visualization (3) creative thinking and (4) visual communication skills may be taken as a "given" expectation of employers at the job interview stage. BIM, as an information modeling tool, is more common to engineering and construction management graduates where there is less professional interest in the above four skills and clearly room for architects and architecture to regain leadership in the building process. In practice, much of the BIM application uptake is left to contractors (sometimes only at the prescriptive behest of clients) who are then forced to engage external IT consultants for advice. Architectural education must respond

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to changing demands, rejecting disciplinary idiosyncrasies and embracing BIM as a core architectural competency.

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WORKING IN THE RESIDENTIAL SECTOR: ANECDOTES OF A 'BOSS LADY' ON-SITE

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ABSTRACT

The Australian Construction Industry faces looming labour shortages, which some argue can be addressed by employing more women. Yet the proportion of females working in the industry is declining. The challenges that women face in the commercial building sector have been well-documented. However, much less is known about female construction professionals working in the residential sector. This exploratory research presents a single case study of the lived experience of a mid-career female Construction Manager (CM) who has been working in the residential sector for over 15 years. Data were collected written self-reflections and semi-structured interviews. Thematic analysis revealed the defining characteristics of the Construction Manager's experience and the findings were then compared with the existing construction literature. There was an over-riding perception of sexism and the need to perform better than men in order to earn respect. The importance of having pre-planned strategies to manage gendered expectations emerged. The analysis revealed that the CM framed her many challenges as an individual "private trouble" to be endured and overcome, rather than structural barriers, which constitute a "public issue", requiring an industry-level shift. Recommendations are made to encourage Industry and policy makers to initiate the structural changes necessary to include women in the workforce. Suggestions are also made for Built Environment educators to support structural changes in the workplace by working with industry and professional bodies; and through incorporating this issue in the curriculum to raise student awareness and explore innovative solutions for the future with young emerging construction professionals.

Key words: construction manager, gender, residential sector, women

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INTRODUCTION

The Australian Construction Industry (ACI) faces a looming labour shortage, with the need for approximately 220,000 new workers by 2020

(Hackett, 2014). Some argue this skills shortage could be addressed by employing more women (Loosemore, 2016) since the ACI employs the smallest proportion of women of all Australian industries (Australian Bureau of Statistics, 2015). Typical of many countries, construction is a non-traditional occupation for women and is the most male dominated and vertically segregated industry in Australia (French and Sheridan, 2010). However, despite an increasing societal focus on gender equity and encouragement for females to pursue STEM careers, the percentage of females working in the ACI has declined, falling from 14.8% in 1995 to 11.7% in 2016 (Workplace Gender Equality Report, 2016).

Moreover, reflecting the global situation, the majority of female roles in the ACI are in lower status office-based positions such as design or support roles (Dainty and Lingard, 2006) with few women working in site-based construction delivery roles (Lu and Sexton, 2010). Women are also under-represented at the managerial level (Dainty and Lingard, 2006; Lu and Sexton, 2010), occupying only 16.1% of ACI managerial positions (EOWA, 2012). The challenges that women face in the commercial building sector have been well-documented both in Australia and overseas. However, much less is known about female construction professionals working on-site in the residential sector, which is the third largest sector of the Industry, employing over 100,900 workers in the construction of houses, flat, units and townhouses (Australian Bureau of Statistics, 2015).

Answering the call for further research on women's careers in construction (Francis, 2017), this study uses a case approach to explore the lived experience of a female construction manager working in the under-explored residential sector. The paper begins with an outline of the study's methodology, describes and discusses the case findings and compares them with the extant literature on women in construction, and then makes recommendations for policy makers, industry and educators to improve the experience of female construction professionals.

RESEARCH METHOD

This case study aims to explore the lived experience of a mid-career, mid-forties, female Construction Manager, Jade (pseudonym), with over 25 years in the CI. Jade has worked for over 15 years in residential construction, the focus of the current study. The case study method provides rich, thick analysis of an issue or context (Yin, 2014). Pattern analysis of the participant's career development was performed and then compared with the extant literature. Data relating to the lived experience of a Construction Manager was collected by asking the participant to write a series of personal reflections on her experiences and through semi-structured interviews conducted over one month and then transcribed.

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Thematic analysis of the self-reflections and interview transcripts was performed to discover emerging themes relating to the participant's lived experience as a Construction Manager. This analysis involved five iterative steps outlined by Braun and Clarke (2006): familiarisation with data through reading the reflections and interview transcripts; generating initial classifying codes; searching for common themes among the codes; reviewing the different themes; and finally defining and naming these identified themes. Three major strands of narrative initially emerged: 1. what initially attracted Jade into the Construction Industry 2. the day-to-day challenges and barriers she experienced on-site in the residential sector, and 3. the factors that helped her to cope, survive, thrive and remain in the Industry. Keywords were subsequently identified to produce a more fine-grained group of five themes, including specific strategies the participant used for coping, survival, thriving and remaining in the residential sector. The findings were then compared and contrasted with the extant literature.

RESULTS AND DISCUSSION

Case context

The role of the Construction Manager in the residential sector

The building process in the residential sector is typically managed by a head contractor overseeing the total project deliverables, mitigating risks, keeping quality on track, tightly managing the timelines and costs. Typically this responsibility is bestowed to the Construction Manager and their Site Management team. A residential building project is broken down into multiple smaller 'trade' packages with each of these sub-contracted externally to specialist trades/suppliers to fulfil. The head contractor's overarching responsibility is to ensure each of these trades perform their tasks in accordance with the delivery program, quality expectations, costs etc. By default, the trades and suppliers become part of the delivery team, as without their specialist skills, the project could not come to fruition. Generally, on a construction site, it is the Construction Manager's role to drive the delivery of the build with his/her team's backing within the many project-related constraints. It is ultimately the Construction Manager's role to maintain project harmony and maintain the delivery vision from start to finish.

Career trajectory

Jade has worked for over half her career (fifteen years) in the residential building sector. Jade's career trajectory closely follows the pattern that Lu and Sexton (2010) found for senior female construction managers working in small British firms. From the beginning of her work life and

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while concurrently studying an undergraduate degree in Architecture, Jade worked in her own building company in partnership with her father. This marks one of two periods of significant length working in her own family company, together with working again as a small business owner for four years mid-career to cater for her family carer responsibilities. This period coincided with Lu and Sexton's first two career stages: compromise; and then pragmatic development endurance.

After 12 years of residential building experience, Jade then worked for seven years for a Tier 1 commercial construction company, attaining the senior roles of Construction Manager; State Project Manager; and then Head of Construction (Residential). This was followed by a further two years as a Construction Manager (Medium Density) for a national volume residential builder. Much of the second decade of Jade's career corresponds with Lu and Sexton's (2010) third stage of female career development: senior management role consolidation.

More recently, Jade has worked for over four years in the construction education sector, a pattern which conforms with Lu and Sexton's (2010) fourth career stage: after achieving career success as a construction manager (the third stage in their career trajectory), women working in small construction firms tend to reinvent their contribution to the Industry. In Jade's case, her new contributions have taken the form of giving back to the greater Construction Industry through educating the upcoming generation of construction professionals, and also by serving as an industry advisor on a state Building Appeals Board.

Emerging themes

The themes and their related subthemes which emerged from the analysis of written reflections and semi-structured interviews are now discussed.

Theme 1 - Passion for the construction industry: "in my genes"

Jade's passion and attraction to the built form developed very early in childhood, conforming to one of the typical patterns for women who enter the CI i.e., having a relative who works in the industry (Bigelow et al., 2015): *"I often comment that 'building is in my genes'…"*. Jade's father was a residential builder who supported her interest from a young age, by taking her on-site, providing her with tools, and explaining the building process first-hand: *"I am a migrant builder's only child. By default, I grew up on building sites, surrounded by architectural drawings, dust and tools"*. Jade's career intentions developed at an early age: *"I knew I wanted to go into the building industry when I was ten years old. My father bought home a box of graph paper a client was throwing out. I begged him to buy me a tape measure, he succumbed. I started to measure our house. I measured door widths, wall widths, window sizes,*

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bricks, tiles...and used these dimensions to design my own homes…hundreds and hundreds of these in the graph paper booklets".

Theme 2 - Securing a firm knowledge foundation

Acquiring technical skills and knowledge Francis' (2017) large-scale survey of 456 professional women in construction found that individual human capital, such as education and experience, was the key driver of female career advancement. Jade's passion for building drove her to acquire construction knowledge and she spent her teenage years in an informal apprentice-craftsman relationship through accompanying her father on-site: *"By the age of twelve … I asked my father to take me onto his projects. He took me with him on school holidays. I asked him about the different construction methods etc. He would spend hours explaining to me why a subfloor was constructed a certain way; about timber framing members, steelwork etc.".*

Professional credentialing Typical of many women in the CI, Jade first studied an Architecture degree at university (Secatore and Scott-Young, 2016). Architecture is a more conceptual, cleaner, office-based design role, and is arguably considered to be a more genteel and socially acceptable professional role for women than on-site construction supervision. However, as Secatore and Scott-Young (2016) found in their study, Jade soon discovered that construction was her true passion: *"I pursued a career in Architecture, and became a registered domestic builder in my early twenties. I practised as an Architect for a few years [5 years], and then moved into building where my real love lay…".*

Theme 3 - Driving past the barrier of sexism

Jade's experience in the residential construction sector was dominated by her perception of the need to deal with ever-present sexism: *"I have personally experienced sexism, particularly in the domestic sector, where it appears that it hasn't evolved anywhere close to its commercial counterparts."* Her experience of gender bias echoes the findings that women in construction are treated differently (Bowen, 2011) and do not have the same networking, mentoring or promotion opportunities as men (Ng et al., 2005). Jade conjectured that the greater presence of sexism in the residential sector may be because the workforce is less educated and more male dominated, exhibiting more ingrained attitudes towards women's competence on-site.

At the start of her career, Jade acknowledged the absurdity of sexism, but accepted it. This equates to the behaviour found by Lu and Sexton (2011) in stage 1 of the female construction manager's career: compromise. She then adopted behaviours to manoeuvre around this barrier, by proving herself to be "worthy" of the construction manager's role: *"The process sounds absurd. Why does a woman need to prove herself, whilst a man of*

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similar experience and vintage doesn't? He just gets on with it, and is accepted as being accomplished. So I just got on with it".

Typical of Lu and Sexton's (2011) second career stage (pragmatic, developmental endurance), Jade consciously devised a number of tactics (described below) to overcome this pervasive sexism; tactics she still employs in each new role she takes on.

a. Laying firm team foundations - Jade recognised the need to prove her worth with her team. *"As a woman in this role, operating predominately in the domestic sector, it has taken an enormous amount of emotional effort just to build a level of underlying leadership trust within my site team. What this meant was that I had to get them to overcome their own perception issues through proving that my experiences and knowledge were worthy of me being their leader. I basically had to sell my abilities to them through proving to them that I knew more technically, and had experienced more in the building sector than most, if not all of them".*
With the team, timing was crucial; she needed to assert her authority from the outset: *"I know I have to set the men straight before I can set the project straight. If I don't do this, I have no credibility and no team backing. This process has to take place immediately, whereby I have to set an expectation and reinforce my reputation before I can set the project expectations".*

b. Building secure footings with other stakeholders - Once the team was on side, Jade then acted on the need to establish her credentials with the subcontractors and suppliers: *"The difference between a construction site and most other workplaces is that the 'team' is not only made up of employees, but predominately made up of external sub-contractors and suppliers, with employees making up a small percentage. It is hard enough [as a woman] to get your own employees on board the delivery journey, especially if the project is large, onerous and troubled, let alone external suppliers and sub-contractors… Once my team were on board, the suppliers and subcontractors were my next vocational conquer. This often evolved over time with interaction, backing from my team regarding my abilities, and sometimes involved conflict".*

c. Leading the pace: be better and tougher than a man - Before commencing her work in construction, her father advised her that she would need to work harder than men and outperform them in order to be accepted and succeed. He told her to *"picture a male in a comparative role and push yourself at least 50% harder…".*

To hold down the role of construction manager, Jade believes that women on-site have to be perceived as tougher than the men they work with. One of her former site supervisors advised her: *"You have to have proverbial 'balls' bigger than the toughest of guys on site".* She felt that

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she would only be respected when she demonstrated she could hold her own against others in the work place. Even then, the admiration of her male colleagues sometimes contained a hint of gendered reproach: "O*ne of the sub-contractors once commented following a heated run in on site regarding resourcing and scheduling: "Geez, you are one tough woman… I'm more scared of you, than I am of any of your blokes on this site".*

Theme 4 - Capitalising on superior relationship skills

Having a planned strategy and tactics to manage her team's and sub-contractors' gendered expectations is related to Jade's superior emotional intelligence and relational skills. As a deliberate strategy, Jade has capitalised on the recognised relational strengths of women in terms of managing conflict, and re-framed situations in rational business terms, rather than in emotional terms, behaviours which the men recognised as excelling their own skills and thus earning Jade their respect and praise. Women are instinctively aware of the importance of managing stakeholder relationships as well as technical issues, a factor often overlooked in the Construction Industry:

"One thing I worked out early in my career was that people do not like conflict, and will often avoid it, or mitigate it other ways. On site what this meant was that my site team were often not comfortable having the 'difficult' discussions with sub-contractors or suppliers (as they often had pre-existing relationships with them and found it hard to confront them). I didn't mind having robust discussions when needed, and would take on this role on site. My focus was the project delivery. I knew any heated discussions were done for the commercial benefit of the project, not for personal reasons. I learnt to make this disassociation early in my building career. What this did inadvertently was elate my team's view of me psychology. In their eyes I was tough and wasn't scared to take any 'blows' for the team. In my last role, I was termed the 'boss lady'...".

Theme 5 - Maintaining resilience

Resilience is the capacity to survive and thrive under adverse or stressful circumstances (Winwood et al., 2013). Despite the many challenges she has faced during her career, Jade has been motivated to continue by her love and passion for the built form and her sense of fit with her career ("*building is in my genes*"). These beliefs correspond to two attitudes that are known to build and sustain resilience: finding one's calling; and living authentically according to one's values (Winwood et al., 2013). Jade recognises the power of her sense of calling and passion to sustain her: *"it is my passion for this industry that drives me past the sexism to achieve greatness and accomplishment".*

Theme 6 - Developing strategies for surviving and thriving

A number of strategies for managing her career as a female Construction Manager in the residential sector emerged from Jade's reflections and

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these are presented in Table 1. These strategies can be classified into actions to facilitate coping, surviving, thriving, and remaining in the residential construction sector, and may well be applicable to women in other sectors in the Construction Industry.

Table 1 Career strategies for female construction managers

Coping strategies	**Survival strategies**	**Thriving strategies**	**Longevity strategies**
Excel on all levels	Work hard	Mentor others	Vocational identity: "It's in my breeding"
No self-pity	Drive excellence	Deliver great projects	Passion: "I love the built form"
Respect others	Never take things personally	Built form fruition	Lay down team foundations to get them "on board".
Tolerate as much as possible	Bite back when necessary	Focus on passion for the built form	
Stay focused on the commercial outcomes	Have the 'difficult discussions'	Drive the project outcomes	

CONCLUSIONS

This case study has identified one professional woman's lived experience in the male-dominated residential building sector. Analysis of her self-reflections and interviews revealed her initial attraction, her subsequent building of knowledge and skills, her experiences in combatting sexism, and the strategies she developed for surviving, thriving and advancing in her chosen career. Case studies such as this provide rich details for understanding the phenomenon of interest; however this method also has the inherent limitation of being unable to generalize the findings to a wider population (Yin, 2014). To counteract this limitation, the emergent themes were then compared with the extant literature on female professionals in the CI. Jade's experiences and career trajectory were similar to findings of other studies, indicating that her experience is a common one for professional women in construction. However, further research is recommended using a larger number of interviewees and also quantitative surveys of female construction managers in the residential sector.

The pervading narrative of Jade's lived experience in residential building is that of the heroic individual effort required by a minority employee to single-handedly combat prevailing sexist attitudes in this male dominated sector. This finding is similar to Lu and Sexton's (2010) and Francis's 2017) studies which reported that women in construction make career

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progress solely by their human capital, i.e., their own individual merit in terms of superior education, knowledge and experience. A woman's career path contrasts to that of a male construction professional, who progresses via the tripartite combination of merit, intrapersonal networks and organisational support (Ng et al., 2005). Jade embraced the individualistic perspective as the status quo, pursuing success in her personal passion through determining to work harder, be tougher and more knowledgeable than any man. Although Jade drew on her father's support as an industry mentor and trainer, she received no support from her employers or peers. Jade is typical of many women in the industry who perceive structural gender bias as the "private trouble" (Mills, 1967) of the individual; a barrier in the workplace which must be overcome by the woman's own striving and tenacity of character; where the burden of adaptation and adjustment is placed squarely upon the individual.

However the requirement for women to perform well beyond normal workplace standards is physically and psychologically unsustainable, and socially inequitable. If the residential building sector wishes to combat projected skills shortages through recruiting more women, then it must recognise that the current structural barriers to women's inclusion and equity constitute a "public issue" (Mills, 1984), which can only be effectively addressed at the wider levels of the workplace, industry, and policy. The lesson for the residential sector is that it must take the initiative to learn about best practice in structural changes implemented recently by leading commercial construction companies. These initiatives include proactive initiatives to attract, recruit and retain more women and then to train, mentor, and promote them into leadership roles.

Educators, too, can play a decisive role in advocating for the necessary structural changes to enable gender inclusion and combat sexism. Through public dissemination of relevant research findings and an informed dialogue with other academics, the industry and professional associations, educators can alert the CI about the structural issues that need to be addressed. Solving the problem of a sustainable future supply of skilled workers will require educators and industry to partner in new and innovative initiatives to provide young women with early exposure to the built form and support their subsequent education, training and career development opportunities. Educators are also well-placed to influence the rising generation of construction professionals by raising students' awareness of the complexity of the gender issues facing the CI as a whole, and the residential sector in particular, and by encouraging future professionals to explore innovative solutions to this current dilemma.

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STRUCTURAL EQUATION MODEL OF STRATEGIES FOR SUCCESSFUL SM IN PPPs

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ABSTRACT

Public Private Partnerships (PPPs) have become an increasingly popular choice for the delivery of infrastructure facilities in the recent years. With the involvement of multiple numbers of stakeholders in a PPP project, stakeholder management (SM) plays a decisive role in project success. However, many issues in the recent PPP projects in Australia as well as around the world can be directly or indirectly related to the SM concerns of a project. The correct selection of SM strategies and a proper framework will help to solve most of the current SM related issues in PPP projects. In an attempt to understand these pre-emptive SM strategies and their links to SM management related issues in PPP projects, a hierarchical structural model was established. Subsequently, by employing the structural equation modelling technique, the model adapts a total of 34 SM strategies and 12 SM related issues. Based on the survey data collected across the industry experts who have exposure to a various number of PPP projects in Australia the results of the model confirmed that the SE is a key to minimise the SM related issues in the PPP projects. Further, interestingly SMO and SM related issues has a positive significant relationship suggesting that more the SMO might lead to more issues. Finally, the relationships between the main tasks of SM were confirmed via the model. With a clear understanding of the significance of these SM strategies in PPP projects the findings could potentially contribute to the PPP project success.

Keywords: Issues, Public Private Partnerships, SM, Strategies and Structural Equation Modelling.

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INTRODUCTION

Stakeholder management (SM) is considered as an effective management approach to fulfil the stakeholder concerns and to develop robust stakeholder relationships in complex project environments (Bourne and Walker 2005). As such, a robust body of literature was developed related to SM in construction projects. However, a very few studies has been undertaken in relation to SM in PPP projects (De Schepper et al. 2014). PPP procurement structure attempts to bridge the efforts of the public and private sectors to provide a facility to be used by the public. Chinyio and Akintoye (2008) confirm the importance of SM in the modern forms of construction procurement such as partnering and private finance initiative. Accordingly many stakeholders are involved whose interests are not always likely to agree. Further, the prior research on the success factors of PPP projects emphasized that stakeholder consideration is a key to attain PPP project success (Tang et al. 2013).

However, the poor management of stakeholder relationships is one of the main reasons for the failure of many PPP projects in global context (El-Gohary et al. 2006, Henjewele et al. 2013, De Schepper et al. 2014). De Schepper et al. (2014) point out the stakeholder relationship issues are directly related to the concerns in ineffective SM approaches. However, no significant effort was put towards to effectively address the current emerging issues related to SM in PPPs. As such, this research tries to address the identified knowledge gap by exploring the SM related issues in Australian PPPs and by investigating the strategies to cope with the issues. The findings herein are the outcomes of hypothesis testing developed during the literature review followed by Structural Equation Modelling. The next sections will introduce the hypothesis through examining the empirical findings in the extant literature. Subsequently the research methodology was explained followed by the research findings and a discussion. Finally, it concludes the findings and inquires further research directions.

LITERATURE REVIEW

Assudani and Kloppenborg (2010) highlight that the major activities related to SM can facilitate and act as a key to project success. And at the same time the scholars have commended that stakeholders play a decisive role in construction projects and satisfying their needs can make or break a project (Bourne and Walker 2005, El-Gohary et al. 2006). Therefore, it is clear that many authors have seen SM as a core element in construction project success. When considering PPP project scenario a variety of authors have highlighted SM related issues in PPP projects. Therefore, it was hypothesised that successful SM will help to solve the current emerging SM related issues in PPP projects. Based on the developed SM frameworks, stakeholder analysis (SA), stakeholder

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engagement (SE), stakeholder management action plan (SMA) and stakeholder monitoring (SMO) are the main components in construction SM. And it was hypothesised that the main stages of SM will remain the same for PPPs although the measurements for each activity may vary due to the inherent uniqueness in PPP projects. As such, it is reasonable to hypothesise the success in SA, SE, SMA and SMO will significantly influence SM related issues in PPP projects.

H1: SA has a significant influence on SM related issues
H2: SE has a significant influence on SM related issues
H3: SMA has a significant influence on SM related issues
H4: SMO has a significant influence on SM related issues

Subsequently, the relationships between the SM stages were also hypothesised. Such hypothesis were developed based on the SM frameworks developed for construction projects. According to the Karlsen (2002) planning activity is followed by identifying activity and the other activities namely analysing, communicating, acting and following up were proceeding activities. In his framework planning, identifying and analysing activities can be considered as the three main processes of SA. Further the analysing activity is followed by the communicating activity. The communicate activity is directly associated with SE. Therefore, it can be established that SA directly links with SE. Further, according to Yang and Shen (2014), SA effects "act" and "continuous support". "Act" was defined as the implementation of the formulated SM strategies which goes in line with the SMA in the current conceptual framework. Therefore, it was established that SA effects SMA. Further, "continuous support" activity consisted with the main activities in SMO and therefore it was established that SA has a direct influence on SMO.

H5: SA has a significant influence on SE.
H6: SA has a significant influence on SMO.
H7: SA has a significant influence on SMA.

The relationships of SE with SMO and SMA were also established based on the existing literature. According to the framework developed by Yang and Shen (2014), "SE profile" stage affects the "evaluating the stakeholder satisfaction with the SE activities" stage. The "evaluating the stakeholder satisfaction with the SE activities" is directly associated with SMO and it can be hypothesised that there is a relationship between SE and SMO. As discussed above the six steps framework introduced by Karlsen (2002) the "communicate" activity affects "act" activity. As explained above "communicate" activity can be interpreted as SE and "act" activity as SMA. Therefore, a relationship was created between SE and SMA. Further, Yang and Shen (2014) "SE profile" stage is followed by "implementing strategies" which confirmed the link between SE and SMA.

H8: SE has a significant influence on SMO.
H9: SE has a significant influence on SMA.

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Yang and Shen (2014), in their developed framework a direct link has been created between "implementing strategies" with two different levels of evaluation activities as "evaluating the effects of SM" and "evaluating the stakeholder satisfaction with the SE activities". These two levels of evaluation activities clear meet the definitions for SMO and therefore a direct relationship was added between SMA and SMO.

H10: SMA has a significant influence on SMO.

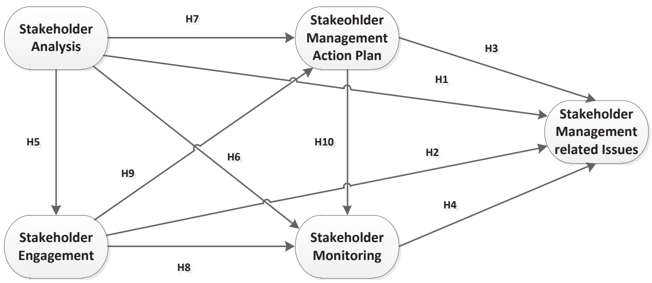

Fig. 1. Hypothetical model for the relationship between SM process and SM related issues

Based on the literature review, a comprehensive list of attributes that clearly represent the five constructs in the model was developed. After a thorough review of strategies for successful SM and exploratory factor analysis, SM related issues, SA, SE, SMA and SMO constructs were further classified under several second factors as shown in Table 1.

RESEARCH DESIGN AND METHODOLOGY

The survey method was adopted to test the hypotheses proposed in this study. A questionnaire survey was designed with a Likert scale of five for respondents to assess the criticality of the SM related issues and the importance of the SM related best practices for successful PPP projects. The questions were phrased to ask the respondents an affirmative response on the relevant strategy impacting the SM related issues in PPP projects. The sample was selected from the managers who were registered in the Australian Institute of Project Management (AIPM), the Australian Institute of Building (AIB) and LinkedIn business networking website (by using the key word search such as PPPs, Public Private Partnerships and Australia). The sample was selected based on their professional role and the experience in a variety of PPP projects. 357 responses were received of which 341 were valid and used for further analysis. The Table 2 shows the profile of respondents.

SEM has become a widely used analytical approach in social and behavioural sciences to explore and test casual relationships in the social sciences over the past three decades (Hair et al. 2009). SEM can be considered as a combination of factor analysis, multiple correlation, regression and path analysis.

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Table 1: Constructs and measurement of SEM

Latent variables	Second order factor	Abbr.	Attributes
Stakeholder analysis	Identification of stakeholders' expectations (SA1)	SA_1	Map stakeholders with the project time line
		SA_2	Classify stakeholders into categories
		SA_4	Identify relationships among stakeholder issues
		SA_5	Rank stakeholders according to their importance
		SA_6	Identify relationships between stakeholders
	Formalised stakeholder assessment procedure (SA2)	SA_11	An in-depth analysis of the opposite & aligned views within stakeholder groups
		SA_10	An in-depth analysis of the political expectations in the public sector
	Consolidation of stakeholder commitments (SA3)	SA_8	Maintain a register of all commitments made to stakeholders before bidding
		SA_9	Share the register of all commitments with the private consortium
Stakeholder engagement	Communication in stakeholder engagement (SE1)	SE_6	Identify the most suitable strategy to engage the stakeholders
		SE_5	Establish community advisory groups
		SE_11	Govt. develops a clear charter on how community advisory groups work
	Formalised stakeholder engagement procedure (SE2)	SE_2	Clear and timely information distribution to general community
		SE_1	Honest communication with general community
		SE_16	Early communication with stakeholders on their concerns
	Transparency in stakeholder engagement (SE3)	SE_8	Govt. agency engages with general community when developing the project brief and design
		SE_9	Public participation mechanisms in shaping bids assessment criteria (by the Govt. agency)
		SE_10	Govt. agency engages an independent party to review the bids
		SE_12	Govt. agency makes the independent reviewer's opinion available to general community
	Risk awareness through stakeholder engagement (SE4)	SE_4	Easy channels (e.g gov. website) for general public to understand the potential social impacts on them
		SE_14	Early involvement of the financial institutions to understand the potential economic risks
		SE_15	Project value evaluation through stakeholder engagement
Stakeholder management action plan		SMA_4	Training for the people who work in community consultation
		SMA _5	Training for the people who manage the operations
		SMA _6	Increase project director's awareness on SM
		SMA _8	Embed SM into business case, procurement and contract manuals
Stakeholder monitoring	On-going stakeholder analysis and engagement (SM1)	SM_6	Continuous communication throughout the PPP process
		SM_7	Ongoing stakeholder meetings between service provider and Govt. during operations
		SM_8	On-going engagement meetings with the operational people
		SM_9	Monitor relationships of stakeholders
	Execution of SM performance evaluation (SM2)	SM_3	Appoint an independent party to monitor the stakeholder matters during initial stage
		SM_4	Appoint an independent party to monitor stakeholder matters during operations
	On-going stakeholder issues identification and monitoring (SM3)	SM_1	Develop Key Performance Indicators (KPIs) to measure SM performance
		SM_2	Measure the performance of KPIs via stakeholder surveys
SM related issues	Issues related to both the sectors (Issue1)	Issue_10	A lack of consideration to stakeholders in longer-term performance monitoring
		Issue_1	The difficulty in assessing the expectations of each stakeholder
		Issue_2	Lack of early consultation with all stakeholders (by the Govt. agency)
		Issue_11	A lack of staff capability in the PPP project delivery
		Issue_3	Non-disclosure of the history behind PPP project to the private consortium
	Issues related to the PPP project decision (Issue2)	Issue_8	A lack of information dissemination to the public
		Issue_6	The political agenda towards PPP project decisions
		Issue_9	A lack of attention to the general public interests
		Issue_7	Financiers' nervousness due to changes in the Govt.
	Issues directly related to the Government sector (Issue3)	Issue_12	A non-efficient conflict management system
		Issue_5	A lack of public engagement sessions when developing the bidding documents
		Issue_4	Overlapping responsibilities among different Govt. agencies

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Table 2: Sample characteristics.

Characteristic		Frequency	Percentage (%)
PPP experience	Less than 5 years	107	31.4
	6-10 years	108	31.7
	11-15 years	63	18.5
	16-20 years	37	10.9
	Over 20 years	26	7.6
Professional role	Stakeholder/relationship communication specialist	51	15
	Project manager	157	46
	PPP Advisory (Commercial, legal, technical)	99	29
	Financier	23	6.7
	Independent reviewer	11	3.2
Sector	Government	122	35.8
	Private	210	61.6
	Others	9	2.6

RESULTS AND ANALYSIS

As the initial hypothesised model given in Figure 1 is based on the theoretical expectations and past empirical findings, it was found to be premature without meeting the standard model fit indices (Molenaar et al. 2000). Recently with the development of SEM in research a variety of goodness of fit criteria have been developed for this purpose (Washington et al. 2010). Generally absolute fit, incremental fit and parsimonious fit are used to judge the fitness of the measurement and structural components (Ong and Musa 2012). A good fitting model should be selected based on the recommended Goodness-Of-Fit (GOF) measures. As such, GOF measures were used to refine the model to improve the fit as shown in Table 3.

Four trials of SEM analysis were undertaken which resulted in eliminating some of the attributes across five constructs. The fifth model was able to achieve the recommended model fit indices. A total of eleven items were deleted due to their low correlations with the variables in the final SEM. Among these variables three were from the SA (SA_2, SA_5, and SA_6) ; four from the SE (SE_11, SE_16, SE_10 and SE_14); two from the SMO (SM_7 and SM_6); one from the SMA plan (SMA_4) and two from the SM related issues (Issue_4 and Issue_7). This elimination was done incrementally as discussed by Molenaar et al. (2000). Based on the final model fit indices the final model is well fitting for the SM related best practices and the SM related issues. The ratio of X2/degree of freedom is 1.542 which indicates that it is acceptable to the data. The root mean square error of approximation (RMSEA) value of 0.043 at p value of 0.05 indicates that the final model cannot be rejected at a high level of confidence. Furthermore, all other essential indices namely Comparative Fit Index (CFI) and Tucker–Lewis index (TLI) values are above 0.90 which

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provide a strong evidence that the fit between the measurement model and the data is acceptable (Molenaar et al. 2000, Jin et al. 2007).

Table 3: GOF measures (Adopted from (Ong and Musa 2012)

GOF measure	Recommended level of GOF measure	Initial SEM	Final SEM
X2/degree of freedom	<5.0	1.543	1.542
Absolute fit			
RMSEA	<0.08	0.047	0.043
SRMR	<0.05	.0759	0.070
Incremental fit			
CFI	>0.9	0.874	0.912
TLI	>0.9	0.862	0.902
Parsimonious fit			
PNFI	>0.5	0.676	0.703
PGFI	>0.5	0.725	0.730

After achievement of the suggested model fit the most parsimonious model was developed using the nested models (Cheng 2001). Accordingly if a structural model has some non-significant paths new relationships which can theatrically justified should be proposed. And at the same time the non-significant relationships should be deleted. These structural models should be developed one by one where later model must be stemmed from previous models. The best fitting structural model should achieve the goodness of fit indices and all almost of the hypothesized paths should be statistically significant (Cheng 2001). The following Table 4 summarises the final significant paths (CR>1.96) (Byrne 1994).

Table 4: Hypothesis testing

Hypothesis	Standardised estimate	Estimate	S.E.	C.R.	Decision
H1: SA has a significant influence on SM related issues					Not supported
H2: SE has a significant influence on SM related issues	-0.45	-1.452	0.449	-3.233	Supported
H3: SMA Plan has a significant influence on SM related issues					Not supported
H4: SMO has a significant influence on SM related issues	0.38	1.202	0.606	1.983	Supported
H5: SA has a significant influence on SE	0.78	1.101	0.257	4.288	Supported
H6: SA has a significant influence on SMO	0.97	1.111	0.295	3.761	Supported
H7: SA has a significant influence on SMA Plan	0.60	1.421	0.501	2.837	Supported
H8: SE has a significant influence on SMO.					Not supported
H9: SE has a significant influence on SMA Plan	0.29	0.502	0.249	2.011	Supported
H10: SMA plan has a significant influence on SMO					Not supported

DISCUSSION

The final SEM model with the significant paths is shown in Figure 2. Accordingly SE has the highest negative correlation (with a standardised coefficient= -0.45) with the SM related issues. SE is used as a generic, inclusive term to describe the broad range of interactions between decision-makers and other stakeholders in megaprojects. It can include a variety of approaches, such as one-way communication or information delivery, consultation, involvement, collaboration in decision-making, and empowered action in informal groups or formal partnerships (Department

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of Sustainability and Environment, 2005). Olander and Landin (2008) confirm this point in general construction projects in relation to external SM and accordingly stakeholder communication to be open; trustworthy; cooperative; respectful; and informative. Tang and Shen (2013)'s study on the factors affecting effectiveness and efficiency during the briefing stage of PPP projects also found that "open and effective communication" is the paramount important factor. According to Zou et al. (2014), most of the practitioners are looking at relationship management as a process of communication. Their results indicated that relationship management is perceived mainly about communicating with clients and stakeholders and maintaining strong relationship with clients. Therefore, it is clear that SE can be considered as the critical process in solving the emerging SM related issues in PPP projects. Interestingly SMO and SM related issues has a positive significant relationship. Due to the long term and dynamic nature of these projects it is very important to monitor the stakeholder matters throughout the PPP project life cycle on regular basis. However, more the SMO might lead to more issues based on the model results. The correlation of SA and SMA plan with the SM related issues were not significant in the structural model. Therefore, H1 and H3 hypothesis were not supported with the results.

The relationships between the SM stages ie. SA, SE, SMO and SMA plan were also established. The relationships between the SA and the SMO is the most significant relationship (with a standardised coefficient= 0.97). Secondly, the relationship between SA and SE was significant (with a standardised coefficient= 0.78). Thirdly the relationship between SA has a significant influence on SMA plan was significant (with a standardised coefficient= 0.60). Accordingly it highlights that the SA is the key in the SM process although it is not significantly lesser the SM related issues in PPP projects. Robinson (2005) confirmed that SA will help to obtain a full picture of stakeholders' concerns, and effectively manage antagonism, prejudice and conflicts between stakeholders. Therefore, it is clear that SA is at the core for successful SM. Finally SE has a significant influence on SMA plan hypothesis was confirmed (with a standardised coefficient= 0.29). The following Figure 2 shows the final model with the emphasised standardised estimates.

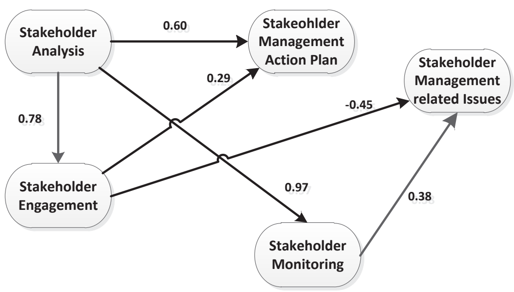

Fig. 2. Final model for the relationship between SM process and SM related issues

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CONCLUSIONS

The Government encounters a considerable challenge in relation to budgetary arrangements and capacity for providing quality services due to the increasing demands for public infrastructure. In such situations PPPs provide a viable alternative to traditional procurement by bringing complementary resources and expertise from both the public and the private sectors. However, the inefficiencies related to SM system in PPPs have been reported as one of the main reasons for PPP project failure in many instances. This research therefore aims to explore a set of strategies which can aim at solving the current emerging SM related issues in PPP projects. This research developed a SM model for PPP projects which shows the relationships between the SM stages and the SM related issues. Our results indicated that effective strategies for successful SE is a key to lesser the SM related issues in PPP projects. Therefore, it is vital to adopt an effective SE practice to manage the most critical issues in the PPP projects. Interestingly, our results indicated that more SMO will lead to more issues in PPP projects. However, it is recommended in theory that the stakeholders and their needs should be monitored throughout the PPP life cycle due the long the term nature of these projects. As there is a contradiction with the theory and the results of the model it is an area for the further research to explore the relationships between SMO and SM related issues. Considering the stages in SM, SA acts as the key and it is the core element in SM although SA is not significantly influencing the SM related issues in PPPs. These proposed relationships will help the decision makers in their choice of SM related strategies to lesser the prevailing SM related issues and to establish a formalised SM framework for PPP projects.

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ROLE OF REGULATORY FRAMEWORK FOR SUPPORTING CONSTRUCTION INDUSTRY IN INDIA

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ABSTRACT

The construction industry has played a significant role in supporting the steady growth of Indian economy over the past. Second only to agriculture, the construction industry constitutes 6% of GDP. With the rapid rate of urbanisation and increasing liberalisation of the economy, the growth in the housing market is also substantial. Under a single national scheme "Pradhan Mantri Gramin Awaas Yojana (PMGAY)" the Government of India is committing to building over 30 million homes by 2022. To support the growth in the construction industry, an appropriate regulatory framework is crucial.

India is a country with a population of 1.3 billion, residing in 29 States and seven Union territories. Total GDP is over two trillion US dollars, growing at more than 7% per annum. No single regulatory framework is currently in place. There is a high degree of fragmentation of policies, which therefore does not support standardised practices or quality in construction.

There are many causes of poor construction quality India. Resolving these causes requires an extensive national effort. That effort is made unnecessarily more difficulty by the lack of common national regulations or standards.

The University of Melbourne is engaged in a Smart Villages research project to build capacity in construction management in Assam, one of the North-eastern states of India. This research will report on a comparative analysis between the regulatory frameworks of Australia and India. Based on the comparative reviews of the regulatory policies, and comparing the scale and operating environments of both countries, the presentation will highlight regulatory gaps to be filled, and enforcement

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practices to be created, if India is to overcome the challenges described above.

Keywords: Construction, Regulations, India, Building.

INTRODUCTION

Construction is a complex process. Projects have long lead times. Construction is capital and resource intensive, and involves many stakeholders over the long lifecycles. The involvement of many stakeholders in construction projects adds significant challenges to managing the entire lifecycle processes efficiently.

There are many causes of poor construction quality in India: design, detailing, drafting, material selection, poor workmanship, lack of proper inspections, formwork failure, geotechnical failures, technical failures, maintenance failures, ignorance, carelessness, negligence and greed (Masurkar and Attar, 2014). Resolving these causes requires an extensive national effort. That effort is made unnecessarily more difficulty by the lack of common national regulations or standards, meaning that these problems must be solved separately for each of the 29 States and seven Union Territories.

As part of a current three-year project, funded by the State of Assam, India, the authors are engaged with research and development activities with a new research entity "Smart Villages Lab" at the University of Melbourne. One of the elements of the project is to conduct research on housing and infrastructure strategies aimed at improving rural life in Assam. The massive growth of the Indian construction industry over recent decades has stressed the industry across several fronts such as skills, resources, leadership, quality control, regulation and compliance.

One of the most aspirational programs under the and ender a single national scheme "Pradhan Mantri Gramin Awaas Yojana (PMGAY)" the Government of India is committing to building over 30 million homes by 2022. The core of supporting such programs for mass housing and infrastructure provisions is a competent and well-developed construction industry.

As the construction industry is one of the most important industry for supporting employments and economic growths of any nation, it is important to understand the barriers and impediments associated with the industry and stimulating efficiencies. Thus, to support the growth of the construction industry, an appropriate regulatory framework is critical.

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By comparing the Indian situation with the Australian construction regulatory regime, this research aims to highlight some of the important issues around the regulatory framework and make a reference to the Indian construction practices. The findings are highlighted in the context of current challenges and opportunities.

AUSTRALIAN CONSTRUCTION INDUSTRY

The construction sector is a significant industry for Australia and represents the second largest sector in the economy. As a result, constraining cost growth and improving productivity has the potential to deliver significant economic benefits nationally. The next instalment of building regulation reform has several options to: reduce the costs of compliance while maintaining health and safety standards; further consolidate consistency in regulatory arrangements across and within jurisdictions; and enhance access to and the utility of key tools needed by users of the building and plumbing control systems to improve outcomes.

A 2012 report by the Centre for International Economics (CIE) found that current building regulatory reforms implemented progressively over the last 20 years are delivering $1.1 billion per annum in benefits, with an additional $1.1 billion per annum in potential benefits yet to be realised. To capture these additional benefits, the next instalment of building regulatory reforms includes:

- enhancing access through a free NCC and improving the document's usebility to broaden understanding and consistency in interpretation;
- reduction in State and Territory departures from the NCC and consolidation of regulation, again to improve national consistency;
- limiting the imposition of higher prescriptive standards for building design and construction than those agreed to nationally through the NCC by other authorities, such as local governments; and
- continued expansion of the NCC to cover all on-site building regulations into a single source document for national consistency and remove unnecessary overlaps in regulation.

AUSTRALIAN CONSTRUCTION REGULATORY FRAMEWORK

The Role of Federal Government

The role of federal government is exercised through the National Construction Code (NCC) and Australian building codes board. The NCC is given legal effect by relevant legislation in each State and Territory. This legislation prescribes or "calls up" the NCC to fulfil any technical requirements that are required to be satisfied when undertaking building work or plumbing and drainage installations. Each State and Territory's

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legislation consists of an Act of Parliament and subordinate legislation which empowers the regulation of certain aspects of building work or plumbing and drainage installations, and contains the administrative provisions necessary to give effect to the legislation.

There is currently a drive towards national streamlining of regulations. The NCC is an initiative of the Council of Australian Governments developed to incorporate all on-site building and plumbing requirements into a single code. The NCC sets the minimum requirements for the design, construction and performance of buildings throughout Australia. NCC 2016 was adopted by the States and Territories on 1 May 2016 and is based on performance rather than a prescriptive code with a high flexibility of implementation to foster a buoyant sector.

The ABCB is required by the Inter-Government Agreement (IGA) to develop a Business Plan annually to ensure that its operations are transparent and accountable (ABCB 2016). The Business Plan reflects the ABCB's commitment to the regulatory reform agenda agreed by Governments. Continuing the emphasis on life safety, the ABCB is working towards achieving productivity gains and a safer built environment through encouraging a greater use of performance based designs. The ABCB operates under an Inter-Governmental Agreement between the nine Governments across states and territories in Australia.

Implementation at the State level

Like India, Australia is a federation of states. Each individual state has its own construction regulations and governance framework that act as primary enabling legislation. Each State and Territory's legislation consists of an Act of Parliament and subordinate legislation which empowers the regulation of certain aspects of building work or plumbing and drainage installations. It contains the administrative provisions necessary to give effect to the legislation and delegates responsibilities for day to day implementation of the act to local councils.

As shown in Figure 1, the Australian construction industry is regulated at the state levels through four levels of regulation.

- State or territory acts of Parliament (enabling legislation)
- State of territory building regulations
- Federal building regulations – the National Construction Code (NCC)
- Reference documents including Australian standards

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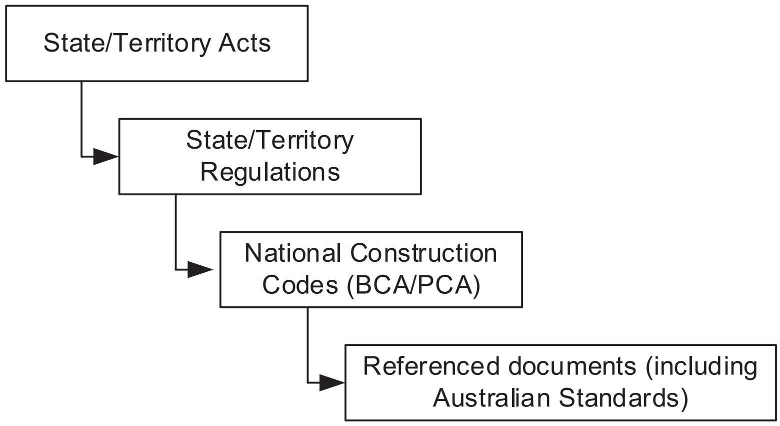

Figure 1 Regulatory levels of Australian Construction Industry

(Source: Australian Government, Building and construction Industry)

State Level Governance of Building and Construction - the Victorian context

Figure 2 depicts the state level regulatory framework in Victoria. As seen, the governance structure is headed by the Ministry of Planning followed by the Victorian Building Authority (VBA) as the key regulatory body (VBA, 2013). Within Victoria an appointed Planning Minister, oversees the role of the Victorian Building Authority (VBA), who regulations act as the primary source of regulations for the state. The VBA is headed by a chief commissioner appointed directly by the Minister for Planning.

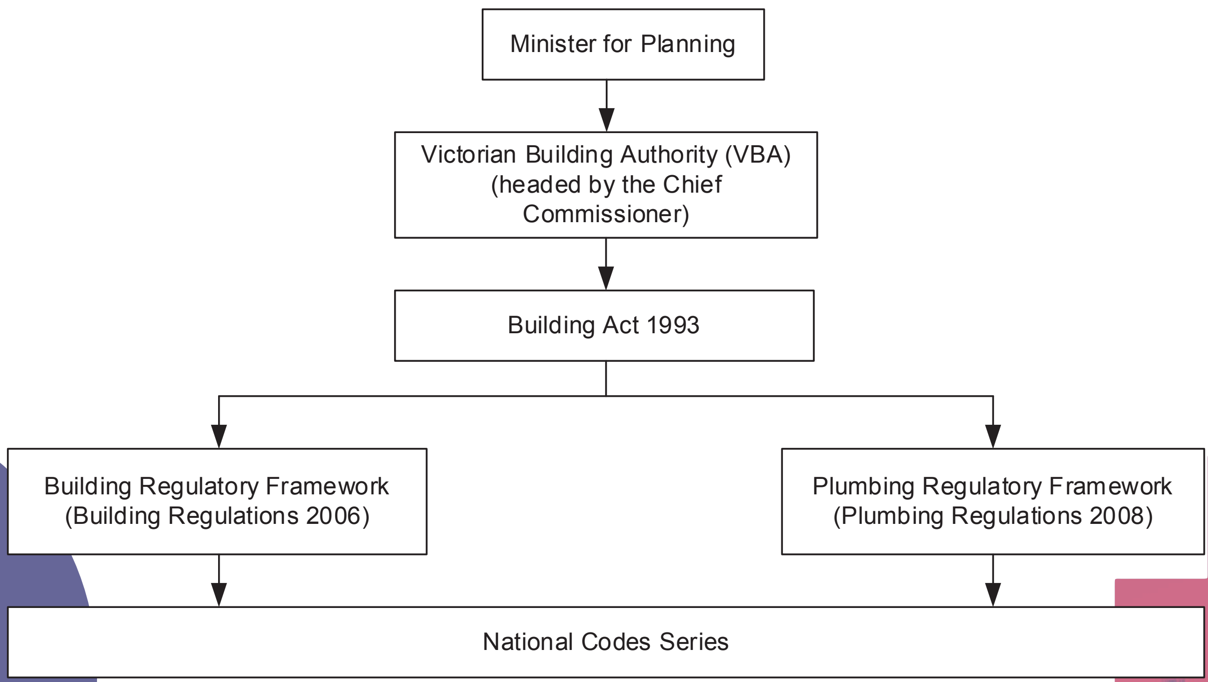

Figure 2 State Level Governance structure (Victorian context)

The role of the Building Act (Building Act 1993)

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The *Building Act 1993* governs building activity in Victoria. It sets out the legislative framework for the regulation of building construction, building standards and the maintenance of specific building safety features (VBA Website)

The objectives of the Act are:

- to protect the safety and health of people who use buildings and places of public entertainment
- to enhance the amenity of buildings
- to facilitate the adoption and efficient application of national building standards and national plumbing standards
- to facilitate the construction of environmentally and energy efficient buildings
- to aid the achievement of an efficient and competitive building and plumbing industry.

The key function of the Victorian Building Act 1993 includes:

- Regulation of building work and building standards
- Providing the accreditation of building products, construction methods, building components and building systems
- Providing an efficient and effective system for issuing building and occupancy permits and administering and enforcing related building and safety matters and resolving building disputes
- Regulation of building practitioners and plumbers
- Regulation of plumbing work and plumbing standards
- Providing for the accreditation, certification and authorisation of plumbing work, products and materials
- Limiting the periods within which building actions and plumbing actions may be brought.

Key functions of the VBA

Building registration. Building registration is usually maintained through the Building Practitioners Board (BPB). The BPB is an independent statutory body established under the Building Act 1993. It oversees the quality and standard of professional services in the Victorian building industry. In doing so, it administers a registration system and monitors the conduct and ability of registered building practitioners.

Victoria's Building Regulations 2006 define nine categories of building practitioner. The categories are: Building Surveyor (Unlimited), Building Surveyor (Limited), Building Inspector (Unlimited), Building Inspector (Limited), Quantity Surveyor, Engineer, Draftsperson, Erector or Supervisor (temporary structures), Builder (Commercial Builder and Domestic Builder), and Demolisher.

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Building and Planning Permits. While the building permit relates to construction activities in the building (new or existing or extension), planning permit relates to the legal processes associated with the land use or development planning. Thus, a planning permit is a legal document for land use and is usually administered by the planning department of the local council. Building permit is usually administered through the Building Surveyors who could operation in private capacity or as part of the building department of the local council.

Building Appeal Board (BAB). If the building permit is refused by the Building Surveyor and there are differences in opinion between the applicant (as owner of the building) and the building surveyor, then Building Appeal Board may be approached to look into the matter for a independent assessment and providing with a mandate. BAB is a statutory independent body established under the Building Act 1993. "The BAB is empowered to determine any matter relating to the Building Regulations 2006 (the Regulations), the Building Code of Australia 2006 and specified provisions of the Building Act 1993 (the Act)." (source: VBA Website).

Violations, enforcements and disputes, are dealt with in a timely manner and depending on scale managed locally or at state level. Claims, appeals, and enforcement are dealt with under Sections 8-10 of the 1993 Act. Clear and transparent liabilities for each of the parties are stipulated in the legislation. Insurance and warranties are mandatory and transparent and the enforcement takes place at local level for minor claims, District court level with violations and inspections undertaken by local councils. Major violations beyond a threshold are usually dealt with at the state level. Disputes are usually resolved through arbitration to a certain level but beyond that can be escalated to the state court system with a relatively short turnaround times for the processing of cases.

CHALLENGES IN THE INDIAN CONSTRUCTION INDUSTRY

In India, the construction industry is also notionally governed by both federal and state regulations. The Building & Other Construction Workers (Regulation of Employment & Conditions of Service) Act, 1996 was enacted to regulate the employment and conditions of service of building and other construction workers and to provide for their safety, health and welfare measures. The Act is applicable to every establishment which employs ten or more workers in any building or other construction work and to the projects costing more than Rs. 10 lakh. The Act contains provision for immediate assistance to the workers in case of accidents; old age pension; loans for construction of house; premium for group insurance; financial assistance for education, medical expenses and

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maternity benefits, etc. The Act is enforced by local factory inspectorates in Indian states, who also have the power to set their own additional rules under the legislation (Haryana Government website).

In practice however, the regulations are rarely enforced in Indian. Large section of the workforce remains outside the legislations scope in Indian construction industry. More than 90% of India's workforce falls outside the scope of the Factories Act, the main piece of safety legislation. Health and safety laws are poorly enforced. Regulators are chronically under-resourced. For instance, one factory inspector for every 506 registered factories is a published figure (CIDC, 2010). Data collection on the incidents and reporting is very poor (CIDC, 2010). In the absence of effective government regulations many multinationals are driving their own safety efforts (Sawhney et al 2014).

Unlike Australia, the bureaucracy in India does not foster entrepreneurship in the sector and this is due to the non-existence of any enabling framework across the whole sector (Shirur and Torga, 2014). Obtaining building permits accounts for a large proportion of total construction costs and the process of obtaining building approval is lengthy. Anecdotally, there are numerous references made to rampant corruption while issuing building permits across the country.

To address some of the issues with the issuance of building permits, the Government of Assam has recently made some changes to the process. For instance, the Government of Assam has mandated that in Guwahati, the approval must be given within 75 days from the date of submission of applications. Areas outside metropolitan Guwahati should issue approvals within 60 days of submission. Absence of response within the stipulated timeframe will be deemed as approved. To address the inefficiencies in the building act, two major building construction bylaws have also been put in place: *the Guwahati Building Construction (Regulation) Bye-Laws, 2014* and *the Assam Notified Urban Areas (other than Guwahati) Building Rules, 2014.* These bylaws are designed to expedite permit approval for both individuals and the state.

COMPARATIVE ANALYSIS

Having reviewed the regulatory framework and the practice of construction, the findings suggests that the Victorian and Assamese regulatory regimes differ in at least in five key ways:

1. *Unlike Victorian 4-tier governance, Assam does not have anything comparable:* The governance of construction Australian construction industry at the state level is considered to have a good basis for

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providing necessary support to the industry for growth and development. The existence of such a multi-tire framework provides a clear division of responsibility sharing and enforcing necessary policies and processes for streamlining the construction activities with a high quality output.

2. *The local government in Assam is almost defunct in terms of planning and regulatory support at the ground level:* Referring to the Assamese practices, there is no any dedicated governance framework for enforcing the planning and regulatory support within the sector. The non-existence of any framework eventually results in sub-standard practices without promoting any competition within the industry. How the industry is complying to the construction specifications from planning to delivery and operations are currently not possible to evaluate without any authoritative hierarchy within the state. Without an appropriate regulatory body and appropriate implementation processes in place, standardisation of construction practices for high quality output is almost impossible especially in the private projects. While the public projects are somehow regulated through the public agencies such as Public Works Department (PWD), for supporting the private sector, a proper regulatory framework is absolutely required in Assam.

3. *Mandatory planning requirements across all tiers of governance:* While the district level Town Planning department oversee most of the urban development, there are not any mandatory planning requirements semi-urban and rural areas in the current practices in Assam. Unlike Victorian practice of stricter enforcement of planning especially at the local government level for suburban developments, lack of any mechanism for controlling the planning issues especially outsides of the city boundaries does not promote any quality construction practice in Assam. This eventually triggers the sub-standard building specifications including noncompliance of national codes for materials specifications and construction processes in Assam.

4. *The is no such separate requirements for building permit, planning permit and the role of building surveyors are not exists at all in Assam:* Unlike Victorian practice for enforcing specific requirements of planning and building permits for new or existing developments, there is no any demarcations of permits in Assamese construction practice. The professional roles and responsibilities of the building practitioners as specified by the Victorian Building Authority are not recognised in the Assam governance system. Thus, there are issues around the core expertise and accountability of the profession for maintaining a high quality output in the sector.

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CONCLUSIONS

Having reviewed the construction related challenges around the Smart Villages projects in Assam, this research compared the governance framework of Assam in relation to the Victorian practices. The Victorian framework is found to be well developed for supporting growths and development of Australian construction industry. However, the current governance framework in Assam is found to be quite inadequate for meeting the growing challenges in housing and infrastructure sectors especially in the rural construction contexts. There is a clear requirement for an improved framework to support the construction industry and address the challenges of sub-standard construction across the state.

While the Australian 4-tier governance framework is considered to be effective for supporting growth and development in the sector, the non-existence of any comparable system in Assamese context is certainly not helping for the industry to be ready for the required challenges in the emerging market. However, the opportunities afforded by the new regulations in Assam are promising in terms of cutting down the red tape and reducing the inefficiencies across the sector. While the approval of permit times has notionally being shortened, to foster an industry to a comparable level as of the Australian construction sector, it is suggested that a four-tier framework similar to that of Victoria could be investigate. Such a framework, which includes both local legislation and national standards, allows the state to foster common standards while at the same time maintaining State autonomy in accordance with the Indian constitution.

While the scope of the research is limited in the review of the Australian practices and comparison that to an Indian context, it is expected that the observations drawn from the literature will be of interest to the audience of the conference and likely generate discussion.

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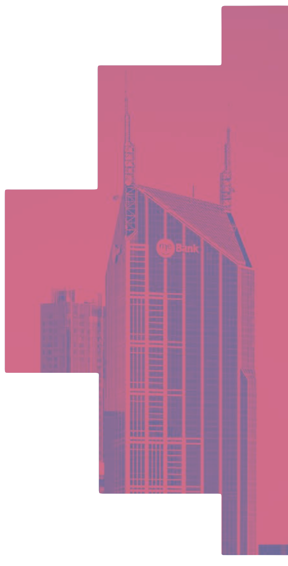

A CHANGE MANAGEMENT PERSPECTIVE ON THE IMPLEMENTATION OF BIM FOR FM

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ABSTRACT

Change plays a significant role in the implementation of any building information modelling (BIM) initiative. For owners transitioning from a traditional facilities management (FM) approach to one supported by BIM, change management is required due to the technological and organisational transformation involved. Yet little is known about the characteristics of how that change is managed. Based on a case study, this paper provides an example of a change strategy employed by a university client/owner during the implementation of BIM-FM integration on a new building project. It describes a 'niche project' change management strategy and its key attributes during the early stages of an owner transitioning to BIM-FM integration.

Keywords: Building Information Modelling, Facilities Management, Change Management.

INTRODUCTION

Almost a decade ago, Eastman et al. (2008), defined as: "…a new approach to design, construction, and facilities management, in which a digital representation of the building process is used to facilitate the exchange and interoperability of information in digital format" (Eastman et al. 2008). Whilst BIM has long been framed as a new approach to FM, comparatively low levels industry maturity have limited BIM's application to the project stages. However, an increasing number of research studies reflect the benefits, challenges and new technologies to facilitate the application of BIM to building operations. The aim of BIM-FM *integration* is to support operations by preventing the loss of building information, improving data access, and automating data entry. As a result, BIM-enabled FM can increase operational efficiency, reduce costs, increase the building lifecycle, and support collaboration and communication across business units. BIM-FM integration thus represents a major socio-technical challenge for the architectural, engineering, construction and operations (AECO) industry.

A growing number of case studies have also been documented, describing the implementation and benefits of BIM-FM integration (Arayici et al. 2012, Kelly

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et al. 2013, Jupp 2013, Codinhoto & Kiviniemi 2014, Kassem et al 2015). Researchers have also begun to identify BIM-FM information requirements (Becerik-Gerber et al. 2012, Pinheiro et al. 2015, Ibrahim et al. 2016, Ashworth et al. 2016) and how they can be managed across the interfaces of the building lifecycle (Jupp & Awad 2017). What these studies highlight is the cross functional nature of BIM-FM integration and its impact on the way an owner/operator runs their business, addresses their market, leverages core competences, and manages data.

This paper explores the key characteristics of change management that result from the implementation of a BIM-FM initiative. It focuses on change relative to the business context, technological and organisational issues of a university owner/operator organisation. The paper presents the findings of a case study based on qualitative interviews with key personnel on a major university building project, and a review of project documents. The paper concludes with a discussion on alternative approaches to change management as owners transition from traditional approaches to FM.

TRADITIONAL BUSINESS MODEL

The aim of any public and private owner/operator with multiple capital investments is 'value creation', obtained by maximising revenues while minimising costs and inefficiencies in building operations and maintenance. Over recent years, value creation for owner/operators has transitioned from simple cost reduction to improving occupant experience and building performance (Jensen 2010). As a consequence, a range of building services and maintenance activities have been outsourced and operations have been fragmented across specialist business units. Whilst outsourcing and specialisation in building operations has increased the level of outward-facing 'openness', such business models can decrease internal collaboration and communication. An owner's development activities relating to project and programme management are often therefore entirely separate from building services and maintenance activities, resulting in the dispersion of knowledge and informationamong different business units. As a result, owners have had to deal with the resulting siloes of knowledge and information.

With the adoption of BIM during design and construction stages, digital transformations have enabled actors within the owner's business units that support building development and project management to engage with BIM technologies, processes and protocols; the increasingly levels of maturity across project stakeholders are assisting these business units in developing BIM competencies, where BIM maturity can be characterised by the use of 'best of breed' technologies, processes and protocols to deliver accurate, coordinated geometric and non-geometric data. The dispersed and siloed design, construction and project management activities are thus slowly being transformed by digital project delivery methods (Boton et al. 2017).

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However to maximize the use and maintenance of buildings and minimize risk and operational costs, the occupancy phase must be considered from project inception. The information requirements that this depends on must therefore be specified and continually managed throughout project phases (BSRIA 2009, Ibrahim et al. 2016, Jupp & Awad 2017). Due to a lack of BIM compentencies across most owner's FM teams, the specification of information requirements and management of control systems to ensure data quality limits the owner's ability to participate and ensure successful BIM-FM outcomes. FM teams remain largely separate from project activities and BIM learner experiences. Compounding this problem, FM units must first undergo digital transformation and integration of their existing tools and processes. Thus support for a BIM-FM initiative requires two key tasks to be undertaken by owner/ operators, including:

1. Transformation of information and communication technology (ICT) and underlying ICT infrastructure, allowing integration of all building related data via appropriate software.
2. Transformation of an interventional organisational view of the extended enterprise, enabling integration of AECO processes and activities across the entire building life cycle.

TECHNOLOGICAL TRANSFORMATION

BIM-FM software can be defined as the 'connective tissue' that enables links between design, construction and FM processes throughout the enterprise. Business operations can be divided into four streams:design management, supply management, construction management, and operations and service management. Each stream forms its own unique 'chain' of software, with interdependent information and data management requirements.

From a software perspective, the chain of design and design management processes is enabled via software such as 3D CAD (Computer Aided Design), CAWP (Computer Aided Workflow Planning) and CAPE (Computer Aided Manufacture). The chain of construction management processes is supported by tools such as: QT (quantity take-off), 4D modelling (4D Planning and Scheduling), and 5D modelling (5D costing and resource management). Running across the design and construction management processes are a number of collaboration tools including EDM (Electronic Document Management) and CPM (Construction Project Management) systems).

The integration pathways of design and construction software are steadily maturing, with levels of interoperability supported by increasingly robust mappings between proprietary software and open standards such as the Industry Foundation Class (IFC) open standard (Liebich 2013). The IFC schema used together with buildingSMART's Information Delivery Manual (IDM) and Data Dictionary (ISO 2007, buildingSMART 2012), also known as the International Framework for Dictionaries (IFD), is capable of describing

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what kind of information is exchanged by providing a mechanism that creates unique IFD IDs, thereby enabling a connection between information from existing and disparate databases to IFC data models (Laakso and Kiviniemi 2012). A number of advanced digital facilities management systems are currently available. However the variety of systems employed by building owners often consists of ad-hoc combinations of 'off-the-shelf' FM systems and BMS (Gökçe & Gökçe 2013). In Australia, many of the larger university building portfolios are managed via a range of disparate software and are equipped with a variety of disparate building automation systems. Thus, their ability to manage maintenance and operations data whilst monitoring performance or predicting maintenance is at best sporadic and at worst inconsistent due to variations in their application across the portfolio. This ad-hoc combination presents difficulties for building owners in relation to the management and upgrade of these systems, and the transformational change that BIM-FM integration represents, as the BMS can consist of a number of components utilizing various information exchange protocols that have to be integrated. Often, these existing tools neither support the exchange of information between different application stages, nor do they consider the extension of an existing wired or wireless monitoring and control system during operation (Gökçe & Gökçe 2013).

Against this backdrop, the linking of BIM and FM software represents a recent development in industry. A variety of facilities and asset management functions are currently supported by various BIM-FM software ranging from basic asset registry functions, managing defects, commissioning data, energy monitoring, emergency response, disaster planning, to maintenance scheduling (Becerik-Gerber et al. 2012). However, geometric and non-geometric data produced by design and construction teams is only useful if it is accurate, appropriately structured and formatted, and capable of being linked to FM and/or the BMS. Common BIM-FM tool functionalities include: (i) the capture of room data associated with the model (e.g., dRofus), (ii) interface support between BIM models and FM/asset management (e.g., Ecodomus), (iii) interface support between data sources *and* associated workflows (e.g., Zutec), (iv) support for building life cycle activities, from feasibility studies to design, construction and operation as well as FM/asset management via interoperable and transparent linkages between data (e.g., VEO M-six and VEO Archive), and (v) audit processes for FM-ready models including maintenance and space data checking and data quality analysis (e.g., Invicara). Further, software to support lifecycle management such as Autodesk's Vault™ together with ERP (Enterprise Resource Planning) solutions are being linked to form data and information integration platforms. This enables project management and business analysis software to be linked with 3D authoring and reviewing tools, as well as from 4D (time) and 5D (cost) software. The linking of information to the 3D BIM provides the backdrop for data integration in product data management softwares such as Vault (Holzer 2014). BIM-enabled FM software is therefore moving towards more tightly coupled integration. However, there is currently no 'out of the box' product to

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provide a one-stop solution to integrate BIM with FM data and current approaches to achieving streamlined data transfer between software vary greatly.

AECO stakeholders are therefore beginning the process of migrating their data storage and management from spreadsheet based approaches to a centralised and integrated web-based platform, increasing the information content and data management capabilities (Holzer 2016). However the establishment and assignment of authoritative 'master' data in the chain of supporting workflows and modelling software, involves upfront planning and documentation. Model authoring tools, together with Product Data Management (PDM) and product lifecycle management (PLM) functionalities are beginning to form the backbone of recent attempts to connect information through-life (Reefman & Nederveen 2011).

From this software point-of-view, BIM-FM integration can be considered as the coordination and synthesis of three levels of ICT: (i) greater consolidation of separate information systems across the owner's entire business into a centralised system for data storage and management, as well as software integration, (ii) greater awareness and planning of the tool ecologies used across AECO activities with detailed specification of data transfer and management, potentially requiring greater use of PDM and PLM functions, and (iii) greater emphasis on local and remote collaboration tools using cloud-based software and web technologies to support remote communication.

ORGANISATIONAL TRANSFORMATION

The availability of new BIM technologies allows for a substantial reshaping of an owner's business processes. This has a dramatic impact on an owner's internal organisation. BIM-FM integration requires a close analysis of the way a building owner is engaging in design, construction and operations processes. That is how they specify and manage requirements, engage in design reviews, collaborate with project stakeholders, integrate processes and information, and collect, use and reuse data.

Business process analysis techniques (Becker et al. 2013) should play a central role in any BIM-FM initiative. In fact, such an initiative requires careful understanding of business processes and the required process reengineering activities. More substantially than in project level deployments of BIM, implementing BIM for FM is a more technology intensive initiative, with even higher levels of organisational change required. Organisational change encompasses both processes and supporting protocols and therefore also includes changes in skills and competencies across the FM team.

Business process reengineering is therefore an essential process in the implementation of BIM-FM initiatives. Such an undertaking requires the analysis of existing procedures and work environments through "as-is" process analysis and the definition of 'to-be' processes. However, existing task

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analysis methodologies, such as unified modelling language, are arguably not well suited to this analysis as they are unable to address required characteristics of BIM-FM integration. This is due to the main purpose of the methodologies being unable to adequately include in their analysis and modelling BIM-FM attributes such as workflow and information. In addition, a careful equilibrium in the level of detail defined in the process analysis and documentation phase is required if it is to be useful.

Whilst an owner executes processes at a single point in time, solutions must be adopted that are as flexible and adaptable as possible. The reengineering phase has to be carried out in collaboration with relevant managers according to the objectives, and may require senior management involvement. For example, if a future 'to be' process includes the use of a model-based function that is expected to be disseminate across departments, it is necessary to establish agreement so as to support organisational change and related technical competency requirements. Communication and documentation of proposed changes to business processes are therefore key.

To assist in the analysis of the required organisational changes, collaborative workshops are being introduced. Techniques that reflect experiential learning approaches (Kolb 1975) are also being used to allow employees, from different FM departments to identify shared knowledge and requirements. In this way experiential learning techniques can help owner organisations (and supporting AECO firms) to redefine the business processes that individuals are involved in through workshop sessions about new ways of working. Workshop enablers can include the use of information requirements templates such as COBie (Construction Operations Building Information Exchange), providing a tool for participants to identify common ground. Virtual simulation of new operational activities can also be undertaken by teams so as to explore 'to be' scenarios; allowing learning of new organisational needs. In this way, drawbacks are identified, allowing refinement of the 'to be' model.

After business and operational process analyses are concluded – with the definition of related information requirements and exchanges – the next aspect of organisational change is to establish the sequence and protocols for software use across project phases and FM departments. With the rapid evolution of BIM-FM software tools, it is necessary to select those that better match both present and future needs. Therefore, particular attention should be paid not only to the internal road map established for the necessary digital transformations to FM strategy but also according to future development.

CHANGE MANAGEMENT STRATEGIES

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Change management plays an essential and core part of any BIM-FM integration initiative. To support such transformations two strategies can be employed: the deployment of a 'niche project with follow up', or an 'overall step-by-step' approach. The first supports the definition of a niche application area inside the organisation to introduce and verify the results and benefits of a proposed change. This approach looks at the transition-transformation process as if it were an experiment to be undertaken in a comparatively short timeframe. Motivated personnel are typically identified to support the niche project, and implementation timeframes are compressed. The goal is for tangible results to be identified from the project's execution and for lessons learned to be documented and used to secure further expansion of the initiative across the entire company.

The second approach devotes much more time to the careful planning and process reengineering of the organisation to include the full company. In this case, the definition of the 'as is' and 'to be' engineering process models play a fundamental role, as do workshops and carefully managed experiential learning sessions. Training is also carefully linked to process reengineering techniques under this change management strategy as they have to drive and control the overall step-by-step implementation. The latter strategy is less common as it is difficult to implement due to the upfront planning and resolution of numerous unknowns in workflow and information requirements.

In the remainder of this paper we explore the first of these strategies, the 'niche project with feedback' change management strategy.

UNIVERSITY BIM FOR FM CASE STUDY

A case-study, with a focus on the extraction of qualitative descriptions was used in this research, establishing the nature of the 'niche project' change management strategy during the deployment of a BIM-FM integration initiative. The project was provided by an Australian University's project management office (PMO) and facilities management unit (FMU), in conjunction with the main contractor.

The case studied describes a large university's initial BIM for FM project, which was based on a 'management contracting' procurement method. The building project comprised of a relatively small, four storey clinical education facility. All design processes and some construction activities were supported by BIM and were collaborative from conception through to handover, involving both the PMO and FMU staff working with the entire project team. Four of the PMO and FMU participants, and two from the main contractor, were selected for interviews based on their level of participation in the project. Two sets of interviews were conducted with these participants. A number of project documents, including the BIM Execution Plan (BEP), BIM-FM Implementation Exchanges, BIM Contract Addendum and internal technical reports) were also reviewed. The purpose of the interviews was to extract qualitative descriptions of change management techniques utilised during the niche project approach to BIM-FM integration. In terms of BIM or digital FM knowledge at the start of the project, the University was in a similar situation to many other organisations, in which there was a general internal consensus that the use of BIM should be adopted in both project procurement and FM, even if the details of what that actually meant were not yet fully understood. The University engaged a BIM consultancy firm to research and report to them how the organisation could adopt a BIM based approach to FM. At the

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conclusion of the white paper it was decided that the new building project was to act as a pilot project trialling some of the papers recommendations.

Thus, together with other members of the AECO project team delivering the building and the BIM consultant, some of the report's recommendations were put into action. As this was a niche project and the project team wanted to create something that was simple, easy to use, accessible, the agreed deliverable was a simple 3D as-built model accessed via a free model compilation viewer with embedded FM data attached to only specific maintainable building elements. The key processes that were undertaken to manage and deliver the FM ready BIM model and the BIM-FM integration system architecture were staged across the project timeline.

FINDINGS

The main features of taking a niche project are presented relative to three areas of BIM-enabled FM, namely: (i) how technical and organisational requirements were identified, (ii) how socio-technical changes were managed, and (iii) how communication on progress was conveyed.

(i) Requirements Identification: A BIM-FM working group was established and consisted of representatives from the university's project management office, the facilities management office, a bespoke data management team, a BIM consultancy and members from the main contractor. Meetings included interviews and presentations from the various stakeholders and interest groups. After several months the working party identified, and had to overcome challenges in the requirements identification process including: (i) How to define a vision for using a BIM based FM solution, (ii) To what extent integration with existing FM software should occur, (iii) What FM information should be captured and in what format, and (iv) Where this information should be stored and accessed. The search for an industry standard or software package to address these needs proved to be a challenge and was seen as a decision "too great for the assembled working group" on this standalone project. Therefore the decision was made to keep the project's data in an open source format for partial integration with the University's existing FM software and employ an approach that allowed for integration into a BIM based FM software at a later stage. To create a link between an element and the rest of its FM data, the main contractor used a set of asset names and IDs in conjunction with the Omniclass classification system to support search functions in the university's existing FM database where the bulk of the FM information for the project was to be stored. Throughout the working group process, the main contractor had a live draft of the BEP which would be continually updated as a result of experiential learning. The BEP was refined as the working group settled on data deliverables, workflows, data formats etc. The final BEP was agreed to by the owner, contractor and subcontractors.

(ii) Management of Socio-Technical Transformation: During this stage, the technical requirements of subcontractors were deployed and found to evolve or increase, meaning that the procurement process for them needed

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careful management. It was necessary to ensure that the main contractor was able to employ subcontractors who could understand and deliver according to the BEP and "buy into" why the accuracy of the data and as built information was especially important on this job. Although the technical aspects of the model were not onerous, there were small technical-related issues that some subcontractors had to overcome, such as ensuring good communication of workflows relating to model use, model coordination, and model management, enforcement of the BEP, and stakeholder management.

(iii) Progress Reporting: The quality and accuracy of as-built models will directly determine the usability and value of BIM data inputs relative to FM data outputs. Progress reporting during these data verification and harmonisation processes were therefore critical. The outcomes of model audit and coordination activities were conveyed regularly to senior management. Documentation and management of model coordination workflows across all disciplines (and datasets) was therefore key to the initiative's success. Verification and validation of building service models against actual installation was undertaken; however the use of laser scanning was seen to be cost prohibitive on this scale of the project. It was therefore proposed that approximately 30 locations per floor, involving building services, be inspected or photographed and visually compared to the federated model. As an audit method, it was perceived to be effective as the photo only needed to indicate that there was a variance between the design and the installation at which point the subcontractor was instructed to coordinate and update the model. The following progress reporting requirements were identifed as key: (i) Ease of access to all geometric and non-geometric data contained in discipline models, where software interfaces had to be simple and free; (ii) Regular communication surrounding the specified tolerance and LOD of the as-built representation of physical assets; and (iii) Use of saved viewpoints for ease and speed of communication. At building hand-over, the main contractor also established a feedback system so as to continue progress reporting and gather information on how the model was or was not being used by the FM team and how the data provide was being integrated.

DISCUSSION

An appropriate coordination effort is required to focus and direct all technical and organisational development activities surrounding BIM-FM integration in the short to mid-term. After senior management commits to the project, a change management strategy has to pursue the following path: (i) ensure regular information to top management on project implementation steps, (ii) ensure regular communication on project progress to all involved, and (iii) apply experiential learning approaches in change management activities so as to secure understanding, buy-in and feedback. With regard to these requirements, the advantages and disadvantages of a niche project approach are shown in Table 1.

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Table 1 Disadvantages and advantages in 'niche project approach'

Advantages	**Disadvantages**
Motivated and involved personnel are made available	Difficulty in feeding forward into the subsequent, full scale, implementation
Quick implementation of the technical solution	Difficulty in evaluating the extent of project achievements and scale them
Focused resource allocation	Project is known only to a few persons
Objective outcomes achieved in short term horizon	Fewer variables to be controlled, which presents additional risks in subsequent full scale implementation

BIM-FM integration relies on a owner organisation's communication and coordination network to support the delivery of accurate as-built models and achieve the benefits of their use in operations. The more buildings in an owner's portfolio, the more a BIM-FM initiative will be complicated and require a clear strategy for change management. A global outlook on the BIM-FM systems architecture and its data processing system is therefore necessary. It is the goal of the information requirements which enable BIM-FM integration to support the network of specialised software tools. Thus information exchange protocols and information requirements management frameworks must be defined by the owner, rather than be left to the project implementation team.

The organisational change management path may be carried out progressively, project-by-project, or via a full-scale step-by-step pathway, according to senior management. The ability to support the correct use of BIM and FM tools will be an important criteria for making this decision. In order to benefit from the advantages of both solutions, mixed change management strategies involving both niche and overall step-by-step approaches could provide a solution. This would enable 'as is' and 'to be' situations to be analysed in full, in order to have a 'global project' that can be presented to senior management for approval. The combination of two different approaches may be most effective to support experiential learning in the first instance and push users to modify their working attitudes towards new reengineered processes, before enabling the required software training and practical use afterwards.

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TALL BUILDING FORM OPTIMISATION: DESIGNINGFOR URBAN RESILIENCE

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ABSTRACT

The paper presents a performance-based design method that combines building and urban objectives for the control of winds impacting on tall buildings at the pedestrian, podium and upper levels. The performance-based method accounts for wind flow and wind load in a form optimization technique that considers a variety of criteria defining urban microclimates, defined by high-density, multi-level building forms subject to acute variations in seasonal wind conditions. The approach is based on the theoretical foundations of 'designing for urban resilience; and highlights the different objectives of this approach relative to existing (tall) building design standards and urban city planning guidelines.

Keywords: Performance-based design, Form optimization, Urban resilience.

INTRODUCTION

In the development and promotion of sustainable urban planning strategy and building design practices, the concept of resilience has become a central aspect of modern cities. By 2050, the United Nations expects 80 percent of the world's population to live in urban areas (United Nations, 2009). In addition, over 310 million people live in cities with a high probability of natural disasters including the effects of hurricanes and tropical cyclones, and by 2050 these numbers are predicted to more than double (Lall and Deichmann, 2012). As cities continue to expand and grapple with the uncertainties and challenges of climate change and unprecedented urbanization there is a growing emphasis on enhancing the resilience of cities (Meerow, 2016).

In the implementation of tall building design standards and urban city development design guidelines, separate policies aimed at the building and urban scale stipulate how a variety of safety, health and comfort requirements must be supported. Recent initiatives surrounding 'designing for urban resilience' have adopted a more integrated 'systems' approach to building design aimed at supporting the survival, adaptation, and growth of cities against chronic environmental stresses and acute

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shocks. Mitigating the impacts of strong or extreme winds at the building and urban city scale is key to urban resilience.

This paper reviews literature surrounding 'designing for urban resilience' and highlights the different objectives of approaches. It furthermore reviews related literature surrounding building standards and urban city planning guidelines, focusing on the Australian Buildings Codes and Development Design Guidelines. The paper then presents a performance-based tall building design method that combines individual building and urban objectives for the control of winds impacting on tall buildings at the pedestrian, podium and upper levels. The performance-based framework therefore accounts for wind flow and load form optimization in urban microclimates, which are defined by high density, multi-level building forms subject to acute variations in seasonal wind conditions.

DEFINING URBAN RESILIENCE

Drawn from the literature of environmental and social sciences research, Leichenko (2011) investigates the notion of urban resilience from the perspective of the impacts of climate change. The study frames urban resilience in terms of the ability of a city or urban system to withstand a wide array of shocks and stresses. Leichenko's study highlights broad agreement among different fields of research regarding the need for cities to prepare for the effects of climate change and implement strategies for urban resilience so as to address a wider range of environmentally driven stresses and shocks. From this perspective, it is argued that efforts to promote urban development, sustainability, and resilience to climate change should be synthesised.

Similarly, Godschalk, (2003) investigates resilient cities focusing on urban hazard mitigation focusing on natural disaster and terrorism. This view considers cities as a complex and interdependent systems that are vulnerable to threats from natural and terrorist hazards. Godschalk's approach proposes a strategy aimed at enabling cities to withstand both types of hazards, defining a 'resilient city' as a "sustainable network of physical systems", including buildings, infrastructure, and communities (encompassing both the formal and informal human associations that operate schools, agencies and organizations, etc.). From this standpoint hazard mitigation is defined as an action aimed at decreasing or eliminating long-term risk to people and property from the effects of environmental hazards. The scope of actions range from the development of structural engineering standards and building codes to land use, planning and property acquisition.

Based on a survey of related literature, a taxonomy of urban resilience is identified across the different environmental and social science domains. This taxonomy divides urban resilience into four categories, including:

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(i) Urban ecological resilience - the ability of a city or urban system to *absorb disturbance while retaining identity*, structure and key processes (Alliance, 2007),

(ii) Urban hazards and disaster risk reduction - the capacity of cities, infrastructure systems, and urban populations and communities to *quickly and effectively recover from both natural and human-made hazards* such as hurricane and international terrorism (Coaffee, 2008),

(iii) Resilience of urban and regional economies - focusing on *the evolution of urban and regional economic and industrial systems* (Pendall, 2009), and

(iv) Promotion of resilience through urban governance and institutions - focusing on questions of *how different types of institutional arrangements affect the resilience of local environments* (Ostrom, 2010).

Based on this brief review of the literature, the authors define urban resilience as a system that able to: (i) respond to uncertainty and change in climate conditions, (ii) respond to associated social–ecological related risks, and (iii) reorganize and recover quickly from such changes, risks and disturbances. Consequently, this research investigates urban hazard mitigation from the perspective of tall building design, focusing on mitigating the impacts of strong and extreme winds at two inter-related scales: the building scale and urban city scale. The authors claim that in designing for these two scales simultaneously, urban resilience objectives can be better addressed.

TALL BUILDING DESIGN AND CONTROLS FOR WIND

High-density cities can be considered as a matrix of wind obstacles, comprising buildings of different sizes and forms, arranged at varying angles with different distances between them. Cities can suffer from poor ventilation and air quality problems, whilst others are subject to strong (sometimes extreme) wind conditions due to their geographical location or improper urban planning. Strong winds can have negative, long lasting effects on cities, their society, the environment, and economy; as is the case in cities such as New Orleans (Kurban & Kato, 2009). As a result, building codes and city development design guidelines target improving the performance of wind loads on buildings and wind flow around buildings. To specify structural wind loads and acceptable wind flows precisely for every possible tall building shape in the context of its surrounding environment would result in provisions so complex as to be of limited use to designers. Therefore the specification of building codes and city development design guidelines involve some compromise.

Building Scale: Structural Wind Load Requirements

One of the main objectives of the wind loading provisions defined in all building codes (e.g., Part 2 of the Australia Standard AS 1170.1-1989), is

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to specify the minimum design loads on structures such as tall buildings. Tall building envelops are sensitive to a number of wind load factors, including the wind velocity approaching the site, the building height and geometry, and the influence of surrounding buildings on the local wind flow patterns. Building codes therefore usually specify loads along the wind direction for common shapes in open and suburban terrain. An exception is the building code AS/NZ 2002, which provides provisions for the cross-wind direction as well. The cross-wind motion is mainly caused by fluctuations in the separating shear layers. Torsional motion can be caused due to imbalance in the instantaneous pressure distribution on each face of the building either due to oblique wind directions, unsteadiness in the approaching flow, partial sheltering and interference from surrounding buildings or due to the building's own shape and dynamic structural properties (Dagnew *et al.* 2009).

Further, studies show that in tall building designs, the crosswind and torsional response may exceed the along wind response in terms of both its limit state and serviceability requirements (Kareem, 1985). Nevertheless, many standards, such as the AS/NZS 1170-2 provide procedures for evaluation of *along-wind* effects. For complex cases, these standards refer to physical model testing using a boundary layer wind tunnel, or BLWT, facility. The approach taken by some codes in predicting structural and wind loads on tall building envelops is to provide formulae that include a measure of conservatism, as might be expected based on the approach taken in deriving the formulae. Williams *et al.* (2003) assert that for small projects (e.g., ≤10 stories) with simple geometries, code formulae are of sufficient accuracy for design purposes and conservative results may not have a major cost impact. However codes such as the AS/NZ 1170-2 recognize that for structures with more complex geometry detailed studies using wind tunnel tests are required since they yield more precise definitions of design loads, and more economical and risk consistent structural designs than code calculation methods.

Urban Scale: City Development Design Guidelines

In response to the mitigation of wind-related hazards, similar requirements are also typically requested by city-based (council) development design guidelines for assessing wind impacts of the design on pedestrians at street level. Concerns surround the effects of wind on pedestrians is primarily related to the reduction of wind velocity and its change rate. A wind impact statement is most often required by Australian city council authorities, which demonstrates via testing the impact that the design will have on the surrounding public realm. For tall building design proposals (typically ≥10 stories), the results of a full wind tunnel test is typically required as part of the development application. Generally, submissions must identify and analyse the effects of wind conditions on pedestrians within the site, on the street at footpath and other surrounding areas. A comparative analysis of the current situation

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against the likely impacts created by the new development is also required; where impacts are shown to be detrimental to current conditions measures to reduce these impacts must be sought.

The City of Sydney Development Control Plan (DCP, 2012) requires a wind effects report based on wind tunnel testing, which compares and analyses current versus proposed wind conditions, where high wind effects at the pedestrian level must be minimized. These provisions apply to buildings that are above 45m. Similarly, the R-Codes of Western Australia (WA 2015) require that high-rise buildings are set back from the site boundary so as to assist in reducing wind impacts. Perth's Planning Scheme (City of Perth 2013) requires a wind impact statement based on the results of full wind tunnel testing for new buildings that above 10m. Similarly, Melbourne's Planning Scheme (City of Melbourne 2016) requires analytical wind study for new buildings to provide a wind effects assessment that demonstrates that wind impacts will not adversely affect the amenity of the public realm and the scheme requires wind tunnel test as an assessment method. In addition, Melbourne's Planning Scheme provides proposed environmental wind criteria, including unacceptable and acceptable wind conditions based on wind velocity and the hourly average wind speed. This criteria assists designers to achieve good pedestrian activation along streets and in open space areas.

PERFORMANCE-BASED FRAMEWORK

The Building Codes and City Development Design Guidelines reviewed in the previous section vary relative to the scale that they are designed to address (structural building scale versus urban scale) and therefore their corresponding level of analysis. What they have in common concerns their typical testing requirements, which rely on wind tunnel testing or computational fluid dynamics (CFD) modelling. However compliance testing of tall building designs against these requirements are not performed until the later schematic and detailed design stages, when important design decisions about the building form and the relationship of the building envelop to its surrounding environment have already been made. Changes to the design of the tall building envelope are therefore costly as significant investment has been made to develop and detail the design across all disciplines involved (architecture, structure and all building services). Further, current building codes and design guidelines do not adequately address the interface between designing for the wind loads that act on a tall building's envelope and designing for wind flows that impact on pedestrians at street level.

During the earlier stages of the design process, decision-making is aimed at searching through a range of potential design alternatives that 'satisfice' (Simon 1956) design requirements and constraints. Relative to climate-related hazards includes strong wind events, this requires finding

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alternative design solutions that satisfy the requirements of building codes and those of city development design guidelines. Most wind load requirements specified in building codes share common standards due to the nature of structural and physical properties. However, design guidelines vary from one region to another according to environmental conditions, including an area's vulnerability to wind-related hazards (tornados, typhoons, cyclones, etc.). When making design decisions about the envelope of a tall building in terms of its form, mass and height, the nature of surrounding wind conditions must first be identified. However, analysing and evaluating design alternatives against specific wind load and wind flow performance criteria in order to meet competing design requirements in the early stages of the design process is a challenging task. It requires an understanding of the nature of aerodynamic behaviour at both the building and urban scales that can only be synthesised using advance modelling and simulation methods (Author A & Author B 2016a). The application of performance-based simulation and optimization provides the necessary design decision support. The ultimate goal of computational simulation methods should not just be the analysis of prescribed shapes, but the automatic determination of the optimum shape for the intended application (Burkard, 2000).

Performance-based simulation in wind engineering has seen increasing in its adoption during the assessment of risk in facilities subject to natural (wind-related) hazards (Huang et al. 2015, Author A & Author B 2016b). Accordingly, the remainder of this paper presents a framework for mitigating strong wind-related hazards based according to different wind load and wind flow criteria. The framework accounts for both building and urban parameters as well as topographical parameters derived from the urban geospatial environment. The framework is based on five modules and seven steps that are carried out in a sequential manner as shown in Figure 1. Details of each module are explained below.

Generative Module: Consisting of objective functions, parameters and constraints. This module defines the objective functions and the boundary of design parameters and constraints. The system boundary is based on three sets of parameters and one set of constraints, namely: wind load and flow performance parameters, geometric parameters defining the criteria for the building envelope, urban parameters defining the criteria of the surrounding urban environment, and the topographical constraints defining slope categories). By assigning different values to the geometric and urban parameters, the values of the wind performance parameters are accordingly adjusted in parallel with the geometrical change of the tall building envelope. Consequently all possible design solutions can be generated. The flexible relations between geometries, wind load and flow performance can then be analysed by the subsequent module. The generative software Rhino/Grasshopper can be readily used as the parametric modelling tool and is suitable due to the flexibility of modelling rendering and design workflow. In addition, Genoform, a plug-in of

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Grasshopper, is adopted as a bi-directional approach to multi-objective problem solving. The model is a surface-based parametric rig composed of geometric primitives (points, polygons, and surface).

Filtration Module: Consisting of filtering functions that can evaluate the results of the Generation Module and compare results with regard to performance parameters derived from building codes and city development design guidelines. The objective of this module is to filter design solutions by discarding unmatched solutions that do not meet the appropriate wind load (building) and wind flow (urban) design criteria.

Filtration Sub-Routine: An external constraints module extends the Filtration Module so as to consider other design constraints relevant to the tall building design brief, such as functional, layout, height and construction constraints, etc.

Simulation and Analysis Module: Consisting of the simulation of the flexible relationships between geometry and wind load and wind flow performance outcomes of the filtered design solutions (resulting from the previous module). The simulation workflow enables the analysis of the impact of the wind load on and wind flow around both the geometrical parameters and performance variables with the visualisation of data points assisting in the confirmation of different performance locations throughout the test site on all X, Y and Z axes. Consequently, the change of performance parameters can be visualized within the system using this module. This assists the designer's understanding of the nature of wind load and wind flow behaviours at both building and urban scales. Autodesk CFD Design is used in this simulation stage as the performance analysis tools include a wide range of simulation tasks relative to wind loads and wind flows. This stage therefore includes multidisciplinary simulation and analysis. It enables the testing of model geometry relative to the building envelope in the context of the urban environment due to its integrated with the city model so as to assess wind performance in a more holistic way. Simulations are run for two scenarios: (1) hazardous high winds in the case of cities exposed to extreme weather conditions, and (ii) hazardous low winds in the case of stagnant air conditions.

Evaluation module: Consisting of comparative assessment. The Evaluation Module provides a quantitative assessment of the level of effectiveness of wind performance across design alternatives, comparing results from the previous module with wind performance objectives and criterion. This implies that there may be no single optimal solution but rather a whole set of possible solutions of equivalent or comparable quality (Abraham et al, 2005). The main objective of this module is therefore to rank design solutions according to wind performance criteria at three levels and to assess performance across these levels, including the pedestrian (0-6m), podium (7-45m) and upper (above 46m) levels.

Form Optimization Module: Consisting of optimisation processes which are aimed at evolving and searching for the most suitable design solution that satisfies the objective function (tested in the previous module) together with relevant compliance criteria (e.g., building code and design guidelines). This module includes a two-part optimization process, namely Design Evolution followed by Form Optimization.

(i) Design Evolution: develops the design solution via mutation of the fittest design solutions' parameters (building and urban parameters) according to all 'performance levels', i.e., pedestrian (0-6m), podium (7-45m) and upper (above 45m) levels. The purpose of mutation is to produce new design properties and features which will allow the system to improve the design solutions' geometric form and performance whilst limiting the number of the feasible alternative design solutions using a proven fitness function identified as a result of the Evaluation Module.

(ii) Search Mechanism: works as a space search mechanism. The designer in this stage searches for the optimum design solutions within the domain of feasible crossbred design solutions using the results of the wind performance objective criterion. The aim of this module is to identify the fittest design from among the available designs solutions based on both the design performance and the wind performance criteria. The objectives of optimization may be variable and not constant depending on design and context requirements relative to wind velocity, directions, and turbulence. However, if the optimized design solution does not fit the performance criteria, the designer can implement changes in the initial design parameters defined in the Generation Module based on the current results, and perform another for run of the Module cycle.

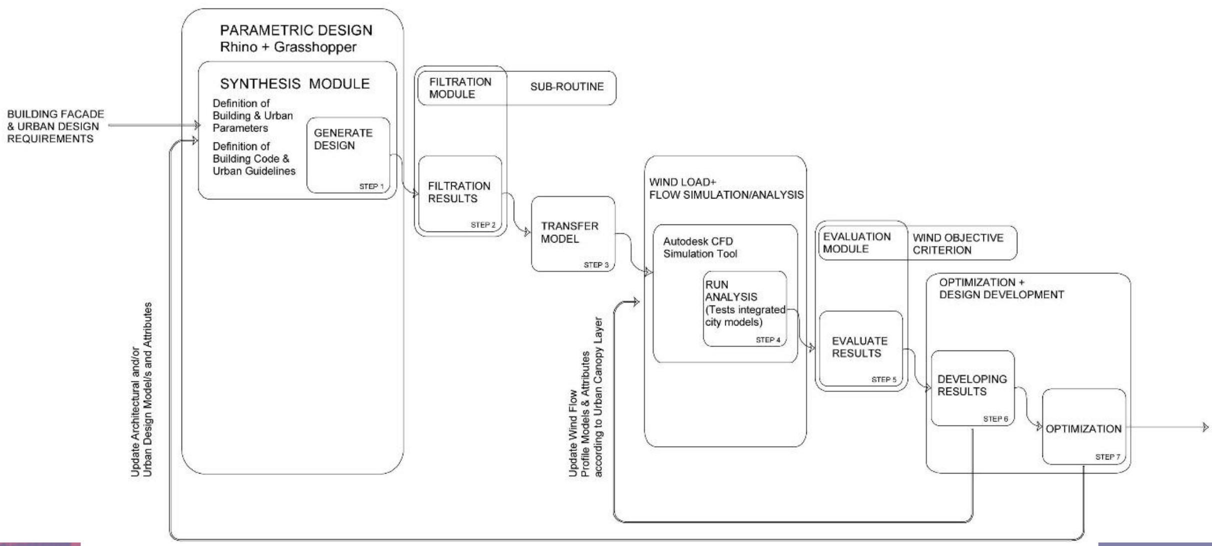

Figure 1: Performance-based Framework for Wind-Related Hazards in the Form Optimisation of Tall Building Design

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DISCUSSION

The paper briefly reviewed literature surrounding designing for urban resilience and highlights the approaches relative to existing building standards and urban city planning guidelines. The paper then presented building codes and city development design guidelines pertaining to the design of tall building envelopes for wind loads and urban wind flow requirements focusing on the Australian cities. The paper highlighted the lack of performance-based simulation and optimization approaches for deigning for urban resilience that account for both the building and urban scales relative to the control of the effects of wind, both in terms of high and low hazardous wind conditions. The authors, therefore, proposed a generative parametric framework based on building and urban parameters and wind performance criteria that can bridge the gap relative to dependencies between building and urban scales, and supports the simulation and optimization of tall building envelopes. The benefit of using the framework surround the performance-based feedback which is valuable to decision-making in the early stages of design so as to mitigate wind-related hazards. Further work is aimed at verifying the framework in a case study of Melbourne.

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SIGNIFICANCE OF CULTURE AND EDUCATION IN DEVELOPING SMART VILLAGES IN INDIA

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ABSTRACT

Over 69% of Indian population that live across 0.6 million villages represent a significant part of Indian Society. However, little has been planned and invested in villages as compared to the urban areas. The fact that villages share only a little less than a quarter of the India's GDP tells us about the lost potential. The sheer numbers are enough to hold as a good argument for planning and dedicated research and investment in this sector. In an effort to empower these rural communities for living with their potentials and contributing positively to the national economy, the creation of the smart villages would not only affect the future of settlements but also force significant changes in the lifestyle in the rural areas. Investigating the elements of the character of the villages and sense of belongingness to the community, this research aims to develop a framework for providing necessary education on the impacts on the vernacular characters of the place while promoting development, sustainability and affordability in the hills of Assam. The next few pages would briefly explain the essential and interdependent components that are part of a smart village, before elaborating on a typical rural house and its cultural elements that are architecturally displayed in the layout and use of spaces by the occupants. This research is only part of understanding the role and significance of culture and community as essential factors for developing rural and remote areas that would be socially acceptable.

Keywords: Components, Cultural value, Education, House, Smart Villages.

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INTRODUCTION

It is not a new trend, where people move towards what is more attractive and popular. What is the next best thing? Which is the next best city to live in? Which is the newest technology? And somewhere in this chase the ones who can afford it, are moving out of villages and rarely coming back and those who cannot are stuck in time, where things are rarely changing around them. In rare occasions that people do return and try to bring something back with them, the new trend does not suit the rural lifestyle, and it either the trend disappears, or it changes the village irreversibly.

There is a commercial wave or a cultural wave that is encouraged as it provides what the inhabitants of the village with opportunities, in the form of trade, entertainment, cultural exchange, socialising, etc. but with this metaphorical wave, some things are lost with the change, such as the quiet and tranquil lifestyle of the country side, or the familiarity or comfort of being at home. As if being part of a smooth sailing boat, where there is a system to how things are run, but with introduction of new equipment or technology, some sub-systems of the main system become redundant or recessive. In such a wave, the village that held an identity through its lifestyle re-identifies it, or in some unfortunate cases, loses it completely and becomes either a ghost village, where most of the youth are in urban areas earning their livelihood, trying to settle down there, while only the elderly, the disabled, women and children stay behind, or becomes just another village that could be any village anywhere.

The hill regions of Assam is such an example of a remote area where even the main head quarter of the district is quite remote or not as urbanised as compared to other towns in the state of Assam. This is demonstrated when one looks up at the sky at night, and you can actually see stars from the roof of the house in the middle of the town, just as you would see from the middle of the agricultural lands a few kilometres out from the main city of Guwahati, Assam.

In this instance, the lack of pollution is actually a valuable asset for the remote areas which come under threat when the wave of urbanisation comes along. Between Urban areas and Rural areas there are both pros and cons to the way of living, and meeting halfway, where villagers do not relocate for better jobs or do not let the modern progress become a pollution to their remote villages, can be a solution for Smart villages. Having a standard understanding of the smart village concept does not

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cater to the diversity of different backgrounds with different topographies and cultural contexts within one state or country.

LITERATURE SURVEY

Smart Villages concept started as off-grid communities that do not rely on the national grid for their energy resource, and it can came to mean more as they took the opportunity to educate, finance and mobilise people of remote rural areas by providing them with opportunities as everyone else, including community involvement and training with long term sustainable solutions. (Cambridge, 2014). Inspired by Gandhian philosophy and thoughts, a SmartVillages Project was conceived for the Indian context. By using the word 'Smart' as an acronym for the definition of the concept, where S= Social, Skilled and simple, M = Moral, Methodical and Modern, A= Aware, Adaptive and Adjusting, R= Responsive and Ready, and T= Tech-Savvy and Transparent, an initiative was launched towards mass movement driven by communities with the help of Information technology as the base on which other opportunities could grow.(Samanvay.Com)

As part of an initiative for tourism, the inhabitants of the Mawlynnong Village in Meghalaya, India, came together as a community to ensure that their surroundings and environment would be clean and even won the status of being the cleanest village in Asia in 2003.*(Pasricha, 2014)* The importance of community driven initiatives or community based contracting is further highlighted in the examples of the 650 schools rebuilt in 8months by the community in Timor Leste ESRP, and the construction of Boat repair shops, Proper Drainage systems, Water supply and Culvert of streams as part of the Indonesia LOGICA in Aceh, post Tsunami where around 200 villages were affected.*(*Week, 2016) To tackle the rural-urban migration that left the village of Hudli, Karnataka, India without its youth, poor, deserted and unemployed; supported by the Khadigram established in 1937 by M. Gandhi, a website for buying pickles made by the women of the village to generate income and employment among women.(TheHudliProject, 2017)

These are obvious examples that along with the state participation in the form of resources, policy-making and management, the participation of the villagers is just as important towards the success of the Smart Villages Initiative. There is a need to generate awareness and enthusiasm from both parties. The added bonus of doing something for your own community along with your community is driving force that enables communities to progress.

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Edward Stack's description of the life and traditions of the Karbi community in the book *The Mikirs,* edited by Sir Charles Lyall, gives an insight to how the people and the life was in the Mikir Hills of Assam in 1884-86. His notes included images and photographs of people in the cultural attire, house and also a plan of a typical Karbi House, along with descriptions of festivals, funeral proceedings and folklore and stories. Translation and explanation of the grammar and dictionary of the language spoken by the community further displayed the social structure and hierarchy of relations within the community. Sir Charles Lyall's involvement in compiling Stack's Jottings and notes included learning the language as well as treading the same journey as Stack, for the best translation possible of the knowledge that Stack had collected over his time in Assam. Sir Lyall also compared the noted to accounts from three other people who were acquainted with the tribe, which were not detailed but did concur with the observations made by Stack. The account recorded and compiled in the book gives a reference picture from where we compare and analyse the changes in the community since then.(Edward Stack, 1908)

Roger barker's theory of behaviour settings is used to explain small-scale social systems, as well as the study of behaviour in its natural environment. Though it is mainly used for research areas regarding psychology, environment and behaviour, the theory can be further applied to understand a community depending on the environment that they have built or maintained around them. Factors that seem to surface from the study would be the key indicators to communicate the translation of the cultural significance of an artefact or practice.(Schoggen, 1989)

RESEARCH METHOD

The Research involves two kinds of methods, where in one, there is an active participation of the community to express their needs as they see fit, and in the other, the study of a traditional house gives insight to the culture and understanding how the customs and traditions of the people of the house have influenced the way the space is built and used.

1) As part of the Conference held at Assam Engineering College, Guwahati, Assam, all the students of the college who attended the 4day workshop were asked to participate and define "smart village" and mention what components or issues would be required to tackle to achieve a smart village.*(*Dr Hemanta Doloi*,* 2016*)*
2) By studying a traditional house and understanding the "Behaviour setting" of a traditional house, i.e., to formulate the elements and

components that are necessary to identify it as a typical version, without which the house would not define as a traditional house.(Edward Stack, 1908; Pangcho, 2006; Schoggen, 1989)

RESULTS

Figure 1 Smart Village components

(Source: Proceedings of the First Workshop on Construction Management and smart villages for Assam, 2016)

Over the first 3 days of the 4-day construction management workshop to initiate and inspire engineering students in AEC, Assam, awareness of their contributions to the rural and less fortunate side of society as professionals, we devised, or in other words, filtered through the possible necessities and components to make up a Smart village.(Dr Hemanta Doloi, 2016)

The categories we arrived at are the following:

Accessibility and connectivity

Most of the villages do not have proper road accessibility and are not well connected to outside world, even in the local level. Villagers would have to walk or row a boat for hours before reaching the nearest market, school, hospital or bank. There are a few occasions where roads and bridges have been built to connect places to each other as well as to less rural/ urban centres, but the lack of maintenance and the erosion due to rain causes problems which almost reverts the built roads to a state of non-existence. Telephone towers are not located in many places and most towns do not

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have a good network or cell reception, which leads to not having a proper internet connection. In such conditions, quite a chunk of the rural population is cut off from the outside world.

Public facilities: Electricity, Water, sanitation and hygiene

Lack of electricity reduces the number of hours for productive work, i.e., how long would the men work in the fields, or how long could women grind the flour, etc. While most of these villages are located close to a water source, it cannot be fully determined whether the water source is sanitary and hygienic. Not having proper access makes it difficult for the people to access public health benefits, in terms of medicine and treatment and also education on how to live in hygienic and sanitised conditions. This in turn leads to health problems that people might face due to unsanitary and unhygienic practices.

Public services

Education is one of the first things that a person from a rural community pursues so that he can start looking for a job with his qualifications to uplift the living conditions of his family and village. There are a few primary schools established in the bigger villages where the children from other neighbouring villages would walk to everyday to be taught by students who have passed the Pre-University Exams, before they are sent to live and study in the closest town for further education. Having bank accounts and savings, and access to health benefits, are just as rare and difficult due to conditions of the roads.

Village environment

Every Village has a quality of air or an ambience about it which is unique and is the cumulative result of all the elements in the village, from the flora and fauna to the lifestyle of the villagers themselves. In the village political system, the land, environment and people is responsibility of the village headman, and the land and sources are in a way owned by him and his responsibility is to see to the wellbeing of the inhabitants.

Village Livelihood

Agriculture and Animal husbandry is among the most common jobs or forms of employment and are the main source of income and livelihood for a person from the rural area. Selling the grains, fruits, seeds and meat from their fields and livestock in the closest market, is how they would earn enough to buy other things that would be required by a household.

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Weaving, carpentry, hunting, pottery and other crafts are skills that do not appear to generate income.

Relationships between households

There is a certain distance or radius around which villagers set up their homes, depending on the natural environment, the house boundary may be demarcated by bamboo fence or by rocks piled up into walls. Normally the fences aren't as high to keep people out but high enough for animals, so that the occupants of the household is alerted. These low fences allow communication with their neighbours and also a visual connection with further off surroundings.

Shelter/ House

Everyone needs shelter, from the weather or from animals, an every village has a style that is optimally designed that is suitable to their practices and requirements with respect to the traditions and customs of the culture they follow. The cultural customs and values are highlighted in the way the traditional house is built and how each space is named and demarcated according to the use by the inhabitants.

The traditional Karbi house

The typical Karbi house is made of wood, bamboo and hay. The wood is used to make the main basic frame structure on stilts minimum of 2ft off the ground to avoid animals from entering the house and also as allow storage of wood, bamboo, hay along with the farm animals like pigs and goats underneath. The bamboo is broken, flattened out and interwoven like a mat to make the walls, and floor in the open stilted areas to allow water run-off from washing or rain. The interior flooring is made of wood. The roof is thatched. Mud is occasionally is areas like the fireplace to keep from rest of the house burning down.

The Karbi traditional house has a simple linear plan with an access connecting the front area to the back and separating the private spaces of the house from the public spaces where the guests would normally be received. Guests are not normally let into the house and if in the case of rain, the overhang of the roof around the house is where, they could wait or meet.

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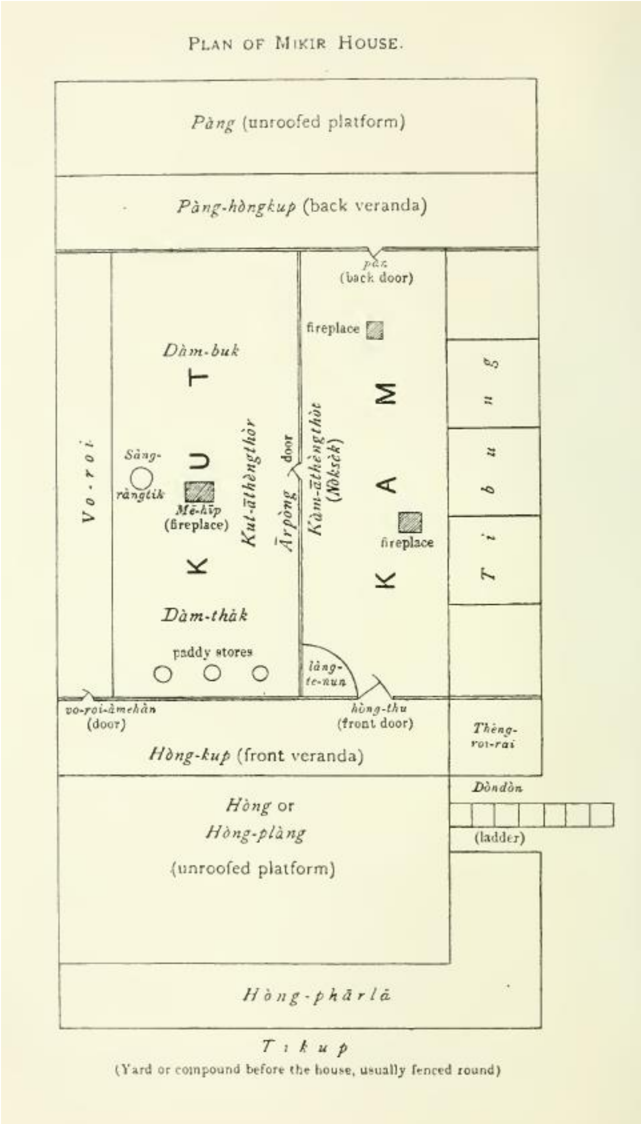

Figure 2 Typical Karbi house

(Source: Edward, 1989)

The traditional house made up of 4 clearly demarcated areas:

- Hong – which is the front veranda or porch. Depending on parts that are shaded or open to sky, the spaces around the Hong have specific uses, such as storage, waiting area, drying of clothes, drying of chillies or other foods. The area opposite to the entry side of the Hong would be wet area used for washing and drying of utensils. The area opposite to their main house would have a small shelter built on an elevated platform from the main house. This is rare and is usually just an extension of the house that is meant for guests, but the son and his bride stay there before they move out on their own.
- Pang – which is the back veranda or sometimes a balcony since there was no access from there, and it would mostly be higher off the

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ground. This area is meant only for females to be used as their private washing and changing area. The handloom would be placed there for the females to weave clothes for the household. It is also used as a nursery during the day.

- Kam – The interior of the house would be primarily divided into 2 areas, the Kam and the Kut, where the Kam is the less private of the two since the access to the pang and the Kut is through it. The area towards the exterior walls and the sloped roof is the Tibung which served as storage for things that would be more frequently used like tools, floor mats etc., or if the couple living in the house had children, they would sleep in the Kam, since the more private area was meant for the Parents, or the eldest couple in the household. It is comparable to a modern day Entry hall or Foyer with sleeping alcoves.
- Kut – The interior most part of the house which was also kitchen area as well as the sleeping area for the eldest couple or parents of the household. It would have only one entry point that would be through the Kam, and though both the Kam and Kut had fireplaces (me-hip), the one in the Kam was meant for cooking while the one in the Kut was only for keeping warm. The household would place the deity or an artefact signifying the deity, on an elevated plank or shelf in the Kam.

The essential elements that would constitute a Kut would be the main fireplace over which the kitchen utensils would hang on a shelf suspended from the ceiling, and the spices and dried meat would be smoked directly over the fire, to be eaten along with the meals as an accompaniment; a single door for entry and exit to the most private and innermost space within the house; and the placement of the deity in the room which would be on the wall closer to the door. This restricted the access of the children towards the further end of the room which is also the main storage place for things that are considered more valuable like jewellery, rice, etc.

The evening meal would be in a way the most important since that is when all the members of the family would be together at the same time would take place in the Kut. They would sit around the fireplace in the Kut on short stools made of wood, as the mother or the eldest female would serve the food starting from the father or the eldest male. The eldest male of the house hold would take a small portion of the food, mix it together, hold it and give thanks to the deity or to Hem-phu Arnam (Heavenly Father, God of all Karbi as per Karbi religion), then keeping it aside as token for the Deity, or Hemphu Arnam, before eating the meal. After the meal, the male

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members and the children would continue to sit around the fire, while the females would clean up after the meal, to catch up with each other, tell stories or discuss current events that might have taken place in the village. It is comparable to a family room or a dining room as family members would take the opportunity to communicate.(Pangcho, 2006)

CONCLUSION

The research executed during the workshop and the traditional House study gives an insight to how customs and traditions practiced by people become the culture that identifies them and they identify with that creates connections between people, their house, environment and the village as a whole. Culture is an intangible element, and through this research is intended to attempt to quantify the quality and value that it holds in the life of a person who is of a rural area and how he perceives it, as compared to someone from an urban area.

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PREFABRICATION TECHNIQUE FOR LOW COST HOUSING IN ASSAM

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ABSTRACT

The housing Pattern of North Eastern part of India can be categorized in three different types. The old primitive type of housing known as Assam type houses are predominant in the North-eastern region. These are mostly residential houses maximum upto single story. The house is generally made of timber. The vertical Post, roofing are made of wood, bamboo supported biomass wall cladding for wall panels are used. With the passage of time this unique method of construction gained importance and newer technology with the use of brick masonry, R.C coloumn and timber roof are being adopted by the local people. This transfer of technology from generation after generation led to the present housing scenario which can be termed as non engineered houses mainly modular and non modular type of construction and R.C.C structures. These non engineered houses have very low vulnerability and poor comfort. The construction type for these houses are dependent on weathering conditions. Therefore there is an urgent need to provide housing with basic facilities for improving living standards without disturbing the natural resources and creating employment opportunities for the local communities. This research aims to investigate the modernisation of the physical structure, construction processes, use of prefabricated components, composite materials, affordability and sustainability of the housing types in Assam.

Keywords: Prefabrication, India, Smart Villages, Rural, Building

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INTRODUCTION

Assam which is located in the North-eastern region of India, Guwahati is the main capital city known as the gateway of North-east. Assam has a population of 3.12 Crores as per census 2011. A significant increase in population has occurred from 2.67 Crores in 2001, leading to a growth rate of 17.07% in a decade. The present affordable housing provision is inadequate in Assam. The rapid growth of population and modernized culture has resulted in a range of housing demands including cost optimization, safety, time constraint and environmental protection. The current research aims to investigate the present housing pattern of Assam, challenges faced by the local construction industry, how the current construction industry may benefit from prefabrication. The housing pattern of Northeast India including Assam are still using the primitive construction methodologies. The typical Assam type house, built in local design with bamboo as wall material and thatch/ backed clay tiles as roof materials is a prominent feature of the housing scenario, especially in rural areas. These houses have a light tin roof and wooden floors that are "highly earthquake resistant", Kaushik, H.B., and Ravindra Babu, K.S. (2012), "Assam-type House", World Housing Encyclopedia Report No. 154, Published by Earthquake Engineering Research Institute (EERI), US and International Association for Earthquake Engineering (IAEE), Japan. The buildings are light, flexible and able to move with the swaying caused by tremors (Kaushik and Babu, 2012). However with the increase in population rate and shortage of land the old Assam type houses have been replaced with multi storied buildings in most parts of Assam. Guwahati the capital city of Assam known as the gateway of Northeast India is experiencing a rapid increase in the number of high rise buildings. Significant improvements to the Assam construction industry are needed to ensure that this expansion leads to safe, efficient, affordable and sustainable housing solutions. Government of India has already launched a Mission/scheme/canvas Pradhan Mantri Awas yojna (Housing for all) to facilitate adoptation of modern and innovative better building materials and green technologies for faster and quality construction of housing. But despite concerted efforts at various levels, the housing problem is not yet solved to the extent required especially in Assam. In Assam construction components are installed and made on site. Installation of the building services is quite rudimentary. Thus research and standardization of non-conventional materials with available natural material such as bamboo, possible in the form of bamboo reinforced fibre panels could be a useful prefabrication technique. Such solutions coupled with advocacy and effective design methodology may lead to broader social acceptance. prefabricated construction could be a favourable solution in Assam providing an impetus to the present construction industry, assisting in improving quality standard of the overall workmanship of housing construction. A thorough literature review is being carried out keeping in view to understand the prefabrication construction in the world.

Prefabrication is the method of construction where both cost and time optimization can be achieved. Prefabrication is the practice of assembling component parts of a structure in the factory or a temporary plant established on the nearby site. These component parts are transported,

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assembled and erected on the construction site. This is a promising innovation and eco- friendly (Brandon & Hampson, 2004).Prefabricated construction can be carried out in poor weather conditions reducing the wasted time and materials since component parts are factory made and on site equipment such as formwork and scaffolding can be largely eliminated. prefabrication is an offsite manufacturing process that takes place at a specialized facility in which various materials and building systems are joined to form a component part of a larger final installation (Gibb 1999). An overall aim of the current research is to acquire knowledge, achieving flexibility and ensure the need of development of present housing scenario over traditional housing system.

The prefabricated housing system and its different developments are not new. The first prefab related house was built in the 1600s in the Massachusetts colony. The process did not become popular until centuries later when several companies began to develop house kits, which contained numbered, precut parts that individuals could put together themselves. The Michigan-based Aladdin Company began to sell these kits by catalog in 1906. Two years later, Sears, Roebuck and Company became known for selling the kits. From 1914 Prefabricated building approaches helped address British and European housing shortages during the post war era. In the 1990's Japan's automated production lines began to produce high quality prefabricated houses in record time. There are numerous examples of buildings that were manufactured in locations such as London, Glasgow, Liverpool in the UK, or Singapore and Hong Kong in Asia, then packaged up on to ships that carried the goods to other countries where they were then assembled. An example of Australian colonial prefabricated buildings is Geelong's celebrated home Corio Villa, which was manufactured by Robertson & Lister of Glasgow, Scotland around1854-5, then erected in Geelong circa 1855-6. Haas et al. 2000,). stated the modularization technique "the preconstruction of a complete system away from the job site that is then transported to the site. The modules are large in size and possibly may need to be broken down in to several smaller pieces for transport". Work is done at an offsite location for increased construction speed and quality.

Hartley and Blagden (2007) stated Prefabricated components are simple building blocks that usually involve a single building trade. The vast majority of buildings constructed today use some form of prefabrication. Applications include timber framed panels, precast panels, steel framed panels, structural insulated panels (SIP's), building envelope/façade systems, composite panels, precast cladding, Light Steel Frame Building Systems, pre-cast structural elements, insulating concrete formwork. A broad range of materials can and has been used in prefabricated construction. This include typical construction materials such as steel , concrete and more un-conventional materials. For example Mansur and Aziz (1982) studied jute fibre reinforced composite and tested it in direct tension , flexure and axial compression impact. This study has shown the feasibility of jute as a low cost housing material for roof and wall panel

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construction. Mathur (2006) has also reported development of building materials with natural resources like jute fibre, coconut coir etc. He also suggested about the use of natural fibre as a composite material for low cost housing. Staiger and Tucker (2008) concluded that specific tensile strength of natural fibre are similar to those of glass fibre. Palanichamy, M.S. et al, (2002) developed prefabrication techniques for residential buildings using a series of pre cast units such as precast R.C.C planks, precast R.C joists are considered for flooring and roofing system. precast columns are also used and the cost analysis was being made. It showed the increase in cost is mainly due to erection charges. Clyde Zhengdao Li, et al, (2015) witnessed serious housing demand in Hong Kong and made to facilitate the development of prefabrication using technologies such as building information modelling, help of information technology tools and corresponding management strategies for the development of housing pattern in Hong Kong. Dineshkumar, N. and Kathirvel, p. 2015 studied the present construction Industry in India and compared the conventional method of construction with the prefab construction method of construction and found cost differences between this two methods. Construction using Prefabrication was tend to be much more expensive than the conventional method in case of individual residential buildings. However the author stated that prefabricated construction is easy to work and reduces project duration. Zhao and Rifat (2016) emphasised for promoting Prefabrication technique seeking for low cost technique using sustainable recycled material such as rammed earth, blast furnace sag, fly ash, straw, use of modular design and advance machinery technique with intelligent computer aided design. Despite there is so much of development since 1960 to 2010 the adoption in prefabricated housing present is not at per. The current paper aims at understanding the shortfalls by the systematic review of the world literature.

METHOD USED

The literature review was primarily done by systematically using online searches with over millions of articles from journal, conferences, publications related to construction in housing. The scope of the search considered recent research published since 1990s and onwards as per the terms shown in the Figure 1.

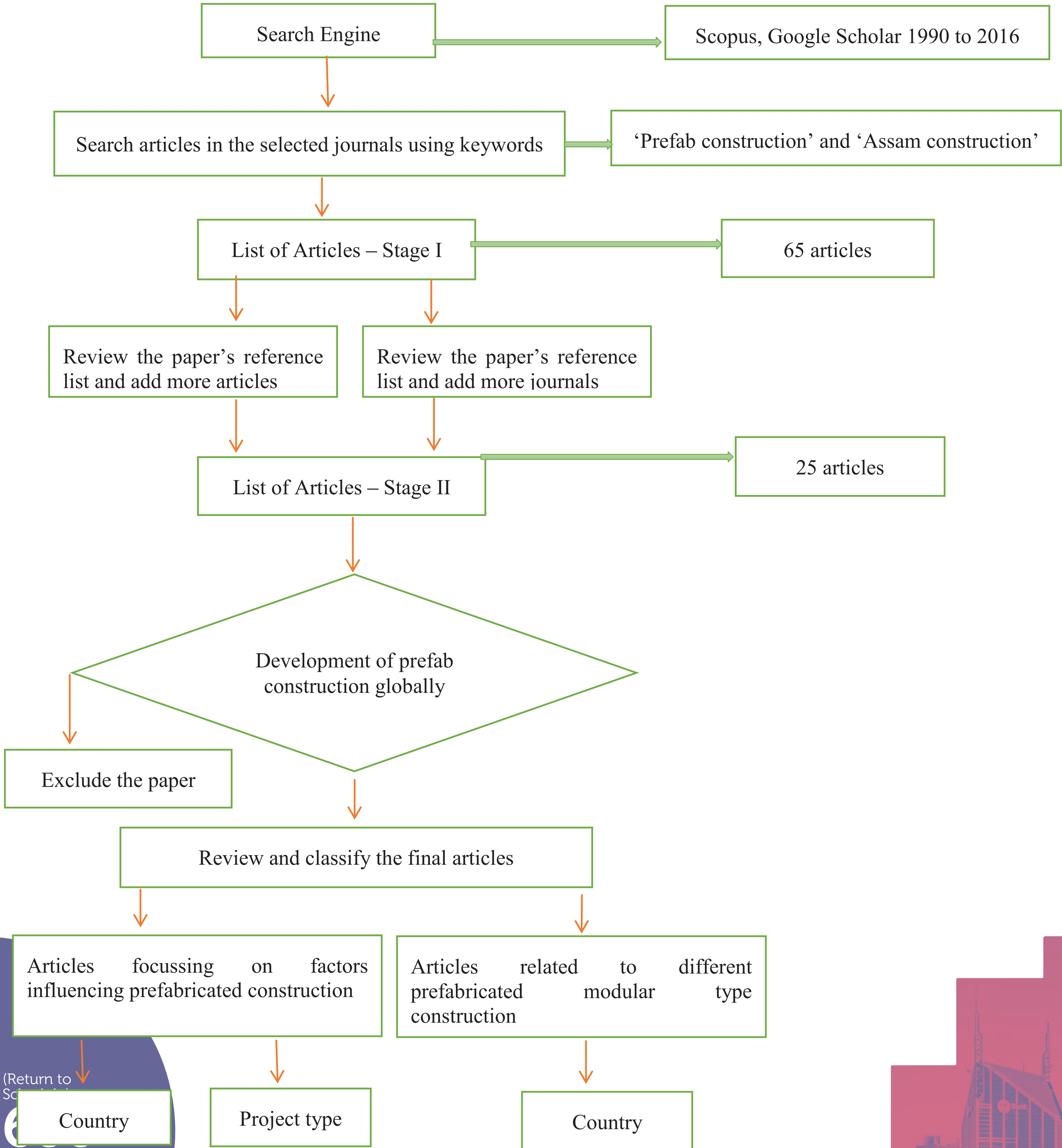

Figure 1. Systematic review of the literature in world context

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ASSAM CONSTRUCTION INDUSTRY AND PREFABRICATION

Assam has the largest economy of the Northeast India. The construction sector is the second-largest economic segment after agriculture. The Northeast is not far behind the rest of the country when it comes to growth in the real estate sector. Assam is fast emerging as an investment hotspot with a growing demand for real estate resulting in huge expansion in both commercial and residential complexes. Guwahati the capital of Assam in the recent years witnessed a sharp increase in the demand for flats, both for residential and commercial purposes whereas in other parts of Assam the demand is greater for private housing construction. However the Real Estate sector of Assam is failing to keep pace with recent housing demands because of its inability to adapt to recent development and technology in the construction fields. The construction of Assam type house is still towards on old and primitive technology. While the Assam type houses are well suited in the state of Assam from the climatic and affordability perspectives, these units could benefit across a number of fronts. Modernisation of the physical structure, construction processes, use of prefabricated units, composite materials, affordability, sustainability etc are all areas need to be addressed. Despite concerted efforts at various levels housing problems are not yet solved to the extent of requirement especially in the Northeast. With the Foreign Direct Investment policy coming into effect and the North East Industrial policy offering competitive support for Assam with cheap land and labour there has never been a more critical time for the development of regulatory mechanism along with improvement to the construction industry to help support upcoming demands.

BARRIERS AND CHALLENGES IN ASSAM

There are numbers of issues and challenges facing in Assam many of which have an influence on the ability to provide affordable, sustainable housing.

Geographical location

Assam which is situated in the isolated part of India has abundant natural resources viz. oil, tea, minerals, dense forest. It shares its boundaries with Bhutan, Bangladesh and surrounded by the states of Arunachal Pradesh, Nagaland, Manipur, Mizoram, Meghalaya and Tripura. Because of its isolated location surrounded by hilly terrain, river and dense forest the cost of construction is generally higher.

Day by day increase in population

The rapid growth of population in Assam causes stress on infrastructure and basic services. As per the census 2011 the growth rate of population

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in this decade was 17.07%. As such with that increasing number of populations will create unemployment and poverty.

Infrastructure and road connectivity

Assam is lacking an effective transportation system and rural road connectivity through its neighbouring states because of its hilly terrain and some local organisation, which are hindering the progress of Assam and the Northeast. Without road connectivity and proper modes of transportation industrial establishment is hard to achieve. In the recent years government has taken measures to improve the connectivity by launching various schemes for the roads, railways and inland water communication.

Natural disasters

Assam is prone to natural flood every year, major of its land is eroded by the river Brahmaputra and its tributaries resulting in major setback in the development of the state, its productions and income. Because of the natural disasters speedy implementation of construction project becomes difficult since during monsoon on site construction work can not be carried out because of heavy rains.

Data based Information technology

In Assam the information regarding housing numbers and their present conditions are not adequate. Innovative Information technology with data based system needs to be monitored and applied.

Lack of skilled personnel

In Assam there is a shortage of skilled personnel. Most of the personnel are unskilled and are from different states. Assam needs to hire skilled technicians from outside for some specific jobs which in turn increases the project cost and makes the project lengthy. Skilled labour with proper training would result a more sustainable construction industry.

Technical Advancement

Assam is still suffering from lack of technical advancement. It still relies on vernacular practices in construction industries and many other sectors. There has been a reluctance to change.

Cost and Time

The another challenges that the construction industry faces is time management. Most of the projects are not time bound, which indirectly affects the cost. Moreover North-eastern region generally experiences heavy rainfall during monsoon so the actual working time for construction is generally restricted to 8-9 months in a year.

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Real estate developers:

Here the real estate developers are mainly builders, architects, engineers and contractors. The adaptation of prefabricated housing solely depends on the willingness of the builders and their acceptance.

Cost and investment return:

High initial cost involvement for the manufacturing processes is one of the barriers for prefabricated housing. The small builders keep themselves refrained from the prefabricated construction housing because of high initial cost additionally there is no innovative technique on prefabricated housing for these small builders to adopt this system.

Lack of manufacturers :

Currently there is a small prefabricated housing manufacturer in Assam albeit these units are out sourced. The construction sector needs to train construction professionals in the area of prefabrication.

Users acceptance :

The acceptance of the users in prefabricated housing with proper robust flexible technique by understanding their sentiments.

Government policy :

Government must formulate some policies and legislation to influence prefabricated housing and open direct competition in prefabricated housing with the traditional one.

Geological stratum_ : The sub soil property of the geological stratum plays a important role in prefabricated construction since Assam falls in highly seismic zone, zone V.

Design codes_: There are no codes guiding the use of prefabricated houses.

Material transport_: The logistics of delivering the housing components at the site needs to be addressed especially for prefabricated units.

Weathering condition : The weathering conditions delays the construction time of the project.

DRIVERS IN ADOPTING PREFABRICATED CONSTRUCTION

Cost and time : Reducing cost and time of construction is the potential key for adaptation of prefabricated construction.

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Real estate developers : Simplicity of connections, with different ranges of sizes and varities of available structural component may help in adopting prefabricated housing.

Workforce : With the existing construction industry the same workforce can be trained for prefabricated housing which may in turn drive them in entrepreneurship creating employment option.

Present demand of housings : with the present demand for residential housing and Government scheme it is becoming necessary for an alternative solution to housing in time.

Expansion of the city_: The main cities in Assam are expanding gradually because of traffic regulatories and land reform policies, this areas needs to be develoed with proper infrastructural policies.

Present modern trend : The present modern trend and culture demands high rise buildings with modern architectural design and safety.

Government policy : The present Central Government focusing largely in the infrastructure development of the north eastern region through "Act East Policy", therefore there is a huge demand and development likely to take place in all front.

Climatic effect_ : Assam experiences high monsoon, due to which actual on site working days greatly reduced causing delays in completion time of the project.

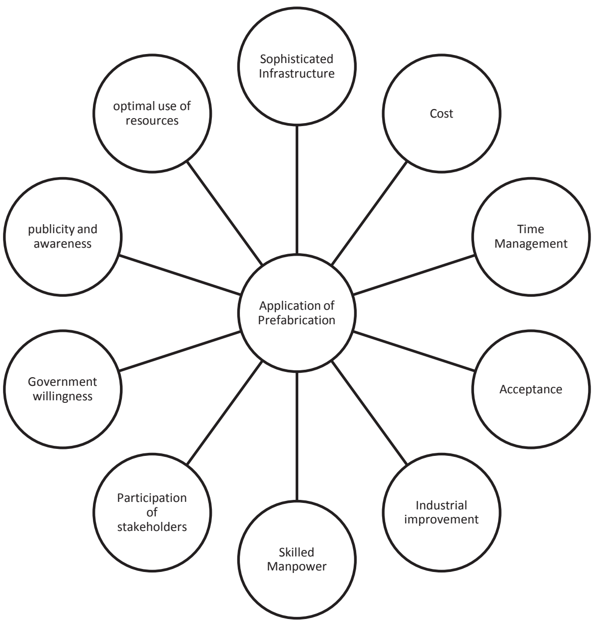

Figure 2. key elements for the prefabrication

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DISCUSSION AND CONCLUSION

Assam has huge scope for modernization of its Construction industry. Prefabrication which is a knowledge based technology still not broadly adopted in India as per the development since 1950. The key issue for promoting prefabrication from the published barriers and constraints are the lack of regulatory body and policies favouring the implementation of prefabricated technology. The most direct influence in adopting prefab technology is cost. However the success of prefabrication technology as a low cost construction technique is the identification of local available materials such as bamboo, rice husk, fly ash etc. that can be used as a part of appropriate structural components with proper design. More over the data base system for the present housing numbers is not adequate. Some innovative information technologies regarding the present housing scenario and available housing needs to be carried out as a database management system. There must be a proper integration and co-ordination between the builders, suppliers and engineers as an outcome for future development. Prefabricated could be potential benefit for Assam in terms improving the local industry, employment opportunities for the local people by providing necessary training thereby developing skilled personal required to be associated with prefabricated construction in Assam or in different parts of India. Housing comfort can be provided as per requirement with better quality and durable factory products. Government also needs to adopt some policies to facilitate the prefabrication approach in terms of incentives or subsidy to attract public sector/private sector for enhancing the prefabrication technology. Future scope may consider structural design consideration of different component parts, safety aspects and the use of locally available materials for creating more sustainable solution. Modernisation of the physical structure, construction processes, use of prefabricated units, composite materials, affordability, sustainability etc are to be examined in such housing units. This paper aims to provide an overview of the present construction industry in Assam, and consider how prefabrication could be a useful construction methodology for North East India. It also aims at adopting prefabricated construction for sustainable and affordable housing in Assam and their challenges and benefit in case of Assam construction industry

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A FRAMEWORK FOR SUCCESSFUL IMPLEMENTATION OF GREEN SUPPLY CHAIN MANAGEMENT (GSCM) IN CONSTRUCTION ORGANISATIONS

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ABSTRACT

Green Supply Chain Management (GSCM) is considered as one of the main efforts, which aim to integrate environmental parameters within the supply chain management. It helps to reduce carbon emissions and improve environmental performances of organisations. As a result of that GSCM has been integrated into the strategic planning of most of the construction organisations. As in case of all radical innovations, barriers or challenges are also expected to be present in the implementation process of GSCM in construction organisations. Hence, it is essential for organisations to identify any barriers that they may face and establish approaches for successful implementation of GSCM in their organisations. Thus, this research aims to develop a conceptual framework by conducting a comprehensive literature review on GSCM practices to address the above-mentioned issues. According to the research findings, the main barriers to implementing GSCM can be categorised into five main categories such as technology, knowledge, finances, outsourcing and management. Furthermore, the strategies to improve GSCM practices in construction organisations include: commitment of top management; changes in existing policies and technologies; improve the awareness of environmental issues; training and education; and implementation of efficient materials and waste management systems. The suggested framework can be applied in construction organisations to identify the key components of GSCM and self-assessment of barriers and strategies to successfully implement GSCM in construction organisations.

Keywords: Barriers, Construction Organisations, Green Supply Chain Management (GSCM), Strategies

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INTRODUCTION

The construction industry practices are criticised due to its negative impacts on the environment such as high energy usage, greenhouse gas emission and waste generation (Deshpande, 2012; Kim et al., 2016; Selvaraj, 2012). Thus, it is necessary to reduce the negative impacts of construction activities on the environment reconsidering its traditional supply chain management (SCM) practices. Thus, green supply chain management (GSCM) can be identified as one of the solutions to resolve the above mentioned issues (Gandhi et al., 2015). Green supply chain management is defined as incorporation of "environmental thinking into SCM, including product design, material sourcing and selection, manufacturing practices, delivery of the final products to the consumers, and end-of-life management of the product after its intended life" (Tyagi et al., 2008). As a result of increase in competitive and marketing demands and regulatory pressures for environmental concerns, organisations tend to integrate green practices in their work practices (Baresel-Bofinger and Ketikidis, 2010). In the process of all radical innovations, barriers or challenges are also expected to be present. Thus, the aim of this research is to develop a conceptual framework for successful implementation of GSCM practices in construction organisations. In order to achieve the above mentioned aim, a comprehensive literature review was conducted focusing on GSCM practices, barriers to implementing GSCM and strategies for successful implementation of GSCM in construction organisations.

LITERATURE REVIEW

The rapid development in the construction industry causes negative impacts on the environmental due to high resource consumption, environmental pollution and waste generation (Wong et al., 2015). Green supply chain management (GSCM) is one of the best strategies to overcome these challenges as it improves the environmental performance of organisations (Balasubramanian, 2012; Minsqiang and Zou, 2011). However, irrespective of the growing awareness, not all construction organisations have successfully implemented GSCM practices due to presence of various barriers in the implementation process (Meythi and Martusa, 2013). Thus, the evolution of SCM into GSCM requires strong commitment from the organisations and related government and other agencies (Jaggernath and Khan, 2015).

Supply chain management and green supply chain management

The concept of SCM was developed in 1970's by focusing on outsourcing, assembling and delivery of products to clients (Mentzer et al., 2001). The Global Supply Chain Forum defines SCM as "the integration of key business processes from end users through original suppliers that provide products, services, and information that add value for customers and other stakeholders" (Lambert at al., 1998). Later on the concept of GSCM has developed by integrating environmentally friendly practices to SCM practices (Jaggernath and Khan, 2015; Sarkis et al., 2011).

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Implementation of GSCM practices has become important part of organisations and GSCM turns into a major and important strategical drive for business organisations. According to Hervani et al. (2005), GSCM comprises green manufacturing, green purchasing, green management, green marketing/ distribution and reverse logistics.

Figure 1: Components of Green Supply Chain Management

As shown in the above figure, GSCM comprises of green material management and planning, green procurement, green marketing, and reverse logistics. Gandhi et al. (2015) stated that competitive advantages of construction companies can be improved by implementing green practices. Similarly, it helps to minimise waste generation, maximise environmental performance, improve cost-effectiveness and improve organisational skills. Therefore, implementation of GSCM plays vital role in organisations at both environmental and organisational levels (Gandhi et al., 2015). As construction is a project based industry, special capabilities are required when implementing GSCM by considering design, procurement, manufacturing, engineering and logistics needs of construction projects.

Implementation GSCM in construction organisations at different stages

Implementation of GSCM in organisations is relatively differed from traditional SCM (Elbarkouky and Abdelazeem, 2013). According to Sarkis (2003), the transition stages of traditional SCM to GSCM implementation include: product lifecycle; operational lifecycle; and waste minimisation.

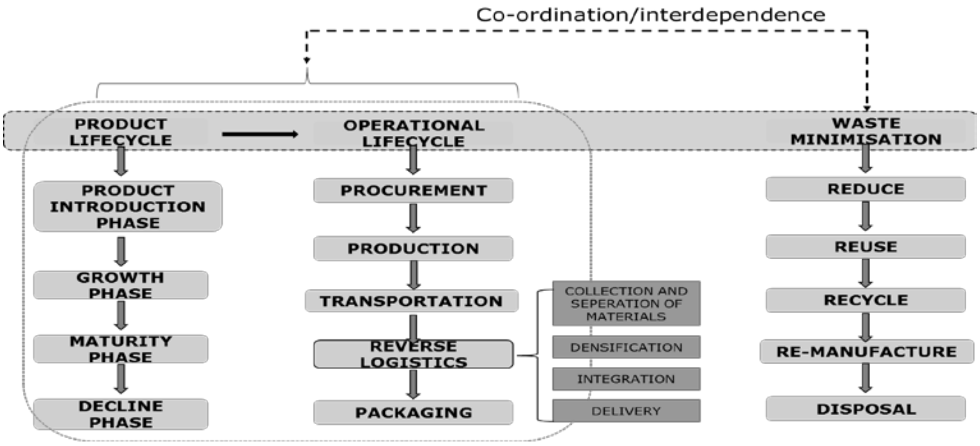

Figure 2: The key transition stages from traditional SCM to GSCM

The product life cycle phase comprises of four phases including product introduction, growth, maturity and decline (Sarkis, 2003). The product introduction phase is the actual design phase. Thus, the impact of the design should be taken into the consideration with respect to energy consumption, material selection and reverse logistics in the manufacturing process along with designing products to be recyclable, remanufactured and repaired (Dube and Gawande, 2011). Similarly, the growth phase facilitates recycling and remanufacturing of the products considering reverse logistics (Dube and Gawande, 2011). Sarkis (2003) highlighted that in order to be environmentally efficient, reverse logistics and improved processes need to be considered in maturity and decline phases of product lifecycle.

The operational life cycle phase includes procurement, production, transportation, reverse logistics and packaging. Dube and Gawande, (2011) define green procurement as "the integration of environmental considerations into purchasing programs, policies and actions". Furthermore, Sarkis (2003) highlighted that organisations should be willing to purchase reusable and recyclable materials from suppliers who have ISO 14000 certifications. Similarly, evaluation of environmental performance should be included in the criteria of contract award along with considerations of cost and quality of performances. Transportation and distribution are important factors in the operational life cycle phase (Elbarkouky and Abdelazeem, 2013). Locations of distribution outlets should be considered in the successful implementation of GSCM in construction organisations to reduce transportation costs, fuel expenses and to reduce pollution from vehicles (Sarkis, 2003). Environmental reverse logistics can be defined as "the return into forward supply chain of reusable and recyclable materials and products" (Sarkis, 2003). Reverse logistics namely considers of four stages: collection and separation of materials transitional processing; densification; integration; and delivery. These stages may differ depending on industry types, product types, clients and organisations requirements (Elbarkouky and Abdelazeem, 2013; Sarkis, 2003). Conservation of natural resources and cost reduction are two

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major benefits of reverse logistics. Green packaging is one of the other consideration in GSCM and it helps to reduce material usage, better space utilisation in storage and reduce amount of resources and tools required in construction activities (Dube and Gawande, 2011).

The last key elemental stage is waste management. This stage can be further sub-categorised into five different stages: reuse; reduce; recycle; disposal; and remanufacture. Total quality management (TQM) and just in time program can help achieve efficient waste reduction practices as well (Elbarkouky and Abdelazeem, 2013). The remaining four processes recycle, reuse, disposal and remanufacture can be termed as end of the pipeline practices (Sarkis, 2003).

Barriers to implementing GSCM in construction organisations

Integration of GSCM into traditional SCM demands careful analysis and systematic changes in existing systems (Balasubramanian, 2012). Companies should be well equipped to mitigate any barriers, which may affect the working of an organisation internally as well as externally. Although it is not possible to mitigate all the barriers simultaneously, a careful analysis of these barriers can help to prioritise them and achieve successful implementation of GSCM (Deepak et al., 2014). The external barriers in successful implementation of GSCM in construction organisations are rigid practices of suppliers, lack of data availability to measure GSCM performance, financial constraints and changing regulations. Internal barriers include the novelty of GSCM, lack of support from top management and lack of communications (Deepak et al., 2014). Other common barriers include lack of public awareness (Zhang et al., 2009), lack of government support for adoption of new techniques (Dube and Gawande, 2011), lack of involvement of top management and lack of transition from traditional to modern techniques. Furthermore, financial constraints (Govindan et al., 2014), lack of organisations mission and vision towards sustainable practices (Deepak et al., 2014), poor knowledge (Parmar, 2016) and communication management techniques (Dashore and Sohani, 2013) were also noted as common barriers. In construction organisations, environmental issues have become more relevant, where organisations need to focus on efficient energy and resource utilisation for environmentally sustainable supply chain. From analysing the barriers and their sources for successful implementation of GSCM, no individual stream acts as the only barrier and that they are inter-dependent on each other.

Strategies for successful implementation of GSCM in construction organisations

Strategies for successful implementation of GSCM include identification of relevant goals and long term planning for managing and achieving these identified goals (Mudgal et al., 2009). The selection of the most suitable

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strategy also depends on regulations, government policies and customer's awareness (Hsu and Hu, 2008). Thus, environmental friendly policies and subsidiaries are vital in the implementation process of GSCM in construction organisations (Balasubramanian, 2012). Trained professionals with appropriate knowledge of GSCM is important to achieve desired results and overcome the barriers of implementation of GSCM in construction organisations (Kamolkittiwong and Phruksaphanrat, 2015). Awareness of professionals, suppliers and end users about GSCM also helps to successful implementation of GSCM in construction organisations (Ibrahim, et al., 2010). Barriers such as lack of knowledge regarding reverse logistics and ineffective designs regarding reuse or recycle can be mitigated by effective reverse logistics management (Govindan et al., 2014).

PROPOSED CONCEPTUAL FRAMEWORK

Green Supply Chain Management (GSCM) has emerged as a crucial organisational philosophy with aims for reducing risks related to environment and having a sustainable future (Dashore and Sohani, 2013). The proper identification of barriers strategies of implementing GSCM can be useful for successful implementation of GSCM in construction organisations. As highlighted in the literature review, GSCM helps to improve the economic and environmental performance of organisations at different levels, as it contains green procurement, green manufacturing, carbon and waste management, reverse logistics and financial management (Gandhi et al., 2015). Similarly, it is necessary to carefully evaluate the key elemental stages involved in implementation of SCM such as product lifecycle, operational lifecycle and waste minimisation. The effective reverse logistics management plays a crucial role in GSCM as it facilitates products recycling, reusability and remanufacturing (Sarkis, 2003).

However, there are numerous barriers to implementing GSCM in construction organisations such as lack of government support, lack of support from top management, financial constraints and lack of public awareness. The strategies for implementing GSCM include: government subsidiaries; commitment of top management; effective reverse logistics management; efficient financial management; increasing public awareness about environmental concerns and efficient waste management and reusability techniques. The figure 3 portrays flow chart with three major sections by noting six main components of GSCM, barriers related to each component and strategies to mitigate those barriers. The suggested framework will help future employers, designers, manufacturers, contractors, suppliers, end-users and existing construction organisations as well during adoption and implementation of GSCM.

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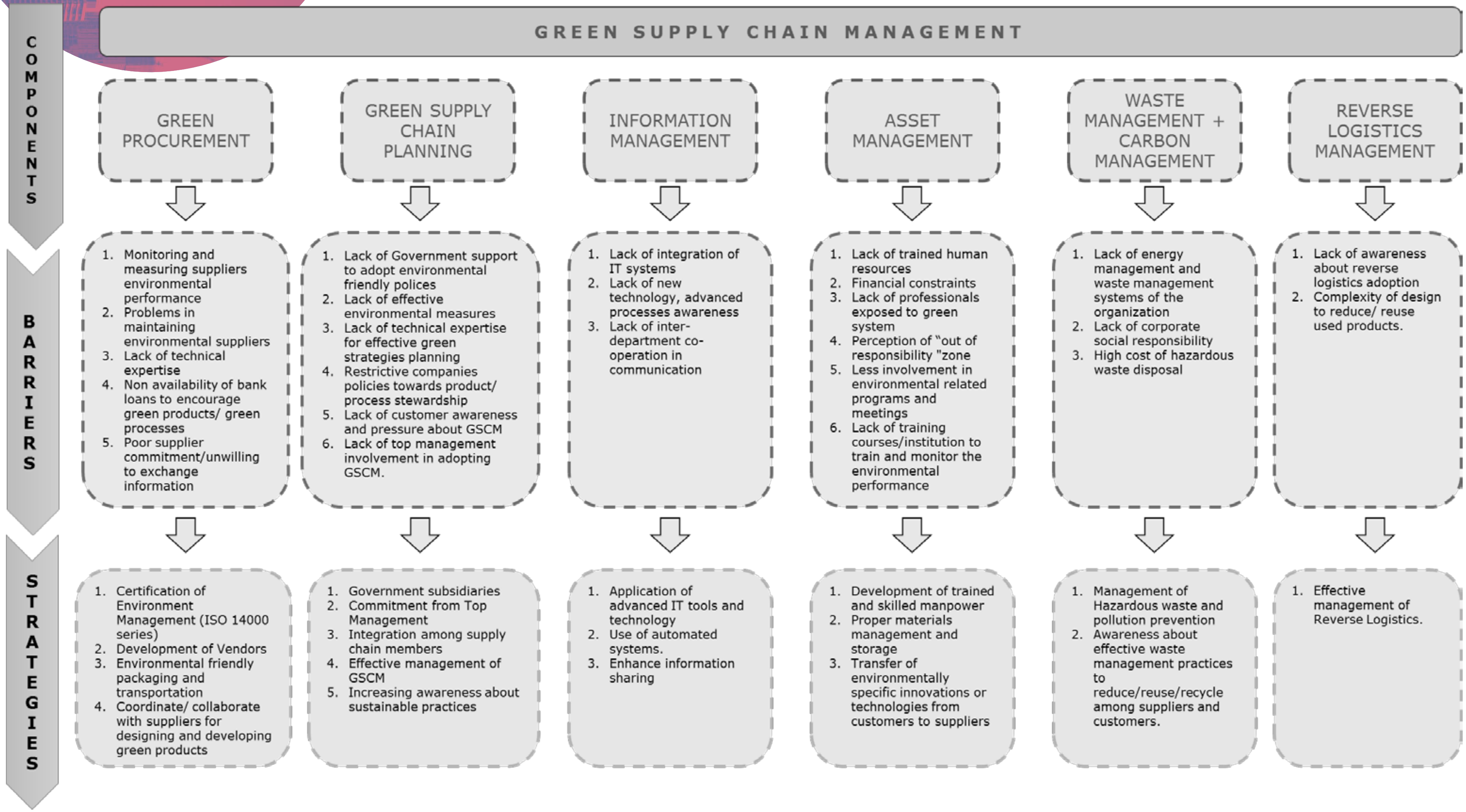

Figure 3: The proposed conceptual framework

CONCLUSIONS

This research study provided an insight to the implementation of GSCM in construction organisations. The critical analysis of existing literature highlighting a gap in the knowledge in relation to awareness of GSCM and its adoption in construction organisations. Thus, in this research a conceptual framework was developed to enable successful implementation of GSCM in construction organisations. The main barriers to implementing GSCM can be identified as technology, knowledge, finances, outsourcing and management. The strategies to improve GSCM practices in construction organisations include: commitment of top management; changes in existing policies and technologies; improve the awareness of environmental issues; training and education; and implementation of efficient materials and waste management systems. This suggested framework can be useful for construction practitioners to successfully implement GSCM in their organisations.

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A FRAMEWORK FOR PROPERTY DEVELOPERS TO SURVIVE IN A RECESSION

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ABSTRACT

Recession is considered as a major threat to the economy as it slows down the economic activities. The property development sector is extremely responsive to these economic conditions. Thus, it is crucial to understand causes, effects and strategies for property developers to survive in a recession without any ill effects. Thus, this research aimed to develop a framework for property developers to identify appropriate survival strategies in a recession. A comprehensive literature review was conducted in this research to achieve the above mentioned aim. The results of this study indicated that recession prompts negative impacts on the property development sector resulting in unemployment, low demand, low production, low revenue, decline in resources and high level of competition. According to the results, the survival strategies were classified into short-term and long-term strategies. The short term strategies include: implementing management tactics; cut down of operating costs; keeping financing lines set up; timely repayment of debts; setting vital new objectives for the future; undertaking short-term developments; specialisation in favoured market; and renegotiating contracts. The long-term strategies include: retrenchment; restructuring; investment; and ambidextrous strategies. Similarly, attention should be paid to predict any changes in the economic environment that can influence property development activities and it is necessary to carefully evaluate the investment activities to increase sales, profits and market shares of property developers. Preparing for a crisis is doubtlessly the ideal approach as it can facilitate both survival and growth. Thus, the property developers can implement these suggested strategies in their businesses to enhance their practices.

Keywords: Effects, Property Development, Recession, Strategies.

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INTRODUCTION

The construction industry is sensitive to economic changes and these changes can affect outputs of the construction industry (Tse and Ganesan, 1997). The world economy suffered from a major recession in the period of 2007-2009, which had severe impacts on various sectors including property development. This can cause enormous strains on organisations resulting in numerous business failures and closedowns (Grusky et al., 2011). The current economic environment in Australia is growing, despite of the fact that there is still a great deal of instability in the economy (RBA, 2015). However, Keen (2016) predicted that Australia is most likely to have a debt crisis in next couple of years. Thus, a recession can directly influence property development by reducing its demand, cash flows and profits (Byrne, 2002). This can place pressure on organisations and they have to set up clear techniques to survive in a recession. The literature acknowledges that property development as a risk prone business due to its procyclical nature. Thus, it is important to understand the field of property development and the threats imposed by recession on it. The organisations that have efficient management plans can survive in a recession (Gulati et al., 2010) and effective strategies to survive in a recession can be planned by identifying the pressures and opportunities during a recession. As a result of that, property developers could not only survive but also use recession as an opportunity to progress in their businesses (Bryson, 1996). Thus, the aim of this research is to develop a framework for property developers to identify appropriate survival strategies in recession. A comprehensive literature review was undertaken by reviewing books, research papers, and web sources to study the context of this research.

LITERATURE REVIEW

Property Development and recession

According to Chitsulo (2013), property development is a process in which the utility of a property or building is improved by developing facilities that meet social, business and infrastructural needs. As developers usually function as investors or traders (Byrne, 2002), the main aim of the property development is to make economic earnings or value addition by the method of development. However, the property development sector is extremely responsive to economic changes and surviving in a recession can be a challenging task for property developers. Iqbal and Vitner (2010) define recession as a substantial downturn in economic activity that can last over few months. As shown in the Figure 1, the duration between peak and trough is recorded as recession whereas the duration between trough and peak is considered as an expansion. A recession can continue a couple of months or years and it causes substantial decline in the economic activities. Likewise, through expansion phase, the economic activity grows significantly and lasts for some years (Emeriti, 2009).

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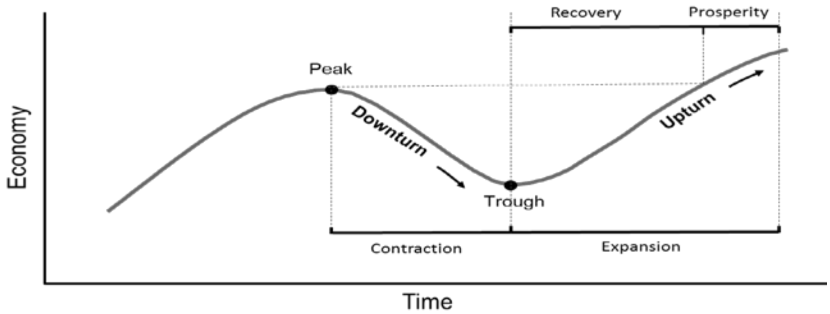

Figure 1 Business Cycle Model

Causes and effects of recession

An increase in inflation coupled with a loss of business and consumer confidence result a reduction of cash supply in an economy is believed to be the root cause of a recession (Grusky et al., 2011). Thus, less quantity of products and services can be purchased using the same amount of money (Allen and Gale 2007) and there could be a drop in the demand for products and services, which leads to drop in production causing cutbacks and unemployment. Investors would fear that stock prices would fall and spend less leading to a stock market crash (Rhoads and Gupta, 2010).

The common negative effects of recession include unemployment, low demand, low production, low profits, high competition and fall in share trading (Grusky et al., 2011). Recession also causes significant reduction in resources that are available for companies as clients spend less and creditors lend less and these lead high competition in property development (Pearce and Michael, 2006). Prices fall due to high competition and lower demand, which in turn results in declining productivity and lower revenue during this period (Domowitz et al., 1987). Similarly, high interest rates can limit liquidity or the available funds for investment (Altman, 2009). Thus, reluctance of banks in providing business loans can cause more business failures and closedowns. Thus, recession can result in lower demand, drop in profits and credits, leading to significant impact on accessibility to resources by property developers (Kaplan and Norton, 2004). However, Bryson (1996) views recession as an opportunity to innovate concepts, technologies and products where industries can evolve. Governments typically respond to recessions by using expansionary macroeconomic approaches like, growing cash supply, improving government spending and reducing taxes (Grusky et al., 2011). Thus, effective management and business strategies should be developed to reduce the negative effects of a recession on property developers.

What Measures Can Companies take during Recession?

The selection of survival strategy depends on company's financial condition and its operating style (Hyland, 2010). According to Banerji et al. (2009), in order to survive in a recession, it is necessary to evaluate

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the company's commercial environment to determine the suitable strategies for survival. These survival strategies can be divided into short-term and long-term strategies as discussed in the following sections.

Short-term Strategies

During a recession, organisations generally start with minor cost controls such as reducing expenditure, cutting travel expenses, discretionary costs and communication (Raghavan, 2009). Gupta (2009) describes that short-term strategies are executed when managers act quickly to solve difficult situations. These actions include: salary cuts; immediate layoffs; postponing activities; pausing employee development; and preserving money. According to Altman (2009), the following strategies can be used by property developers to survive in a recession.

- Closely monitor stocks to avoid accumulating dead stocks until the desired price is obtained or due to low requirements
- Pay off debts in time to reduce debt exposures
- Negotiate with contractors, clients and landowners
- Reduce costs of advertising
- Search for new markets
- Monitor costs and expenditures
- Undertake short period development projects

Employee management and performance management become the key factors to progress during a recession. The accountability system of the company should be able to provide employees a proper focus and understanding that their workloads (Bidya, 2009). These strategies could include: decisions on employees; new developments/ products; control of capital expenses; and research and development (Banerji et al., 2009).

Long-term Strategies

Companies need to implement major business strategies to achieve their long-term goals. Arieu (2007) defines business strategy as a long-term plan that is developed to achieve a specific aim or a number of objectives. Typically, firms have to evaluate their strategic position before choosing a business strategy by understanding market pressures, threats and opportunities, assessing their strategic ability and evaluating the enablers and limitations of selected strategy (O'Gorman 2006). The common and most effective business strategies include: retrenchment; restructuring; investment; and ambidextrous.

Retrenchment Strategy

Retrenchment strategy mainly aims in stabilising the company's financial situation (Kitching, 2009). The outline of retrenchment involves: downsizing; closure of facilities; consolidating work and departments; decentralization; decrease in employment; reduce expenses in marketing, staff training, research and development; and high level of control

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(Pearce and Michael, 2006). In a positive perspective, retrenchment strategy enables firms to reassess their portfolios by considering their core values and it provides rationale for expanding productivity by reducing working expenses and divestment of non-core resources. However, cost and resource cutting can be a spontaneous response to poor economic situations, instead of a proactive alteration of the firm as it reduces ability of businesses perform well when economy expands (O'Neill, 1986). There are two divisions of retrenchment strategy such as cost cutting strategy and asset reduction strategy. Cost cutting strategy mainly focuses on the firms' ability to operate efficiently by lowering profits and maintaining a steady cash flow. Cost cutting techniques are expected to provide optimistic results compared to income generation and asset reduction (Lantham, 2009). Asset reduction strategy involves in sale of assets with low income and other unimportant properties (Kaplan and Norton, 2004). However, Hofer (1980) stated that these measures must be carefully and intentionally considered as those could have potential damaging effects on companies. These strategies can give one-time infusion of non-operating cash flow that may moderate income strains brought on by economic uncertainty (Bryson, 1996).

Restructuring strategy

Restructuring strategy involves in making the company profitable by reorganising the ownership, operational, legal and other structures, or better management of resources to meet its current needs. It also includes financing loans, selling part of the firm to investors, restructuring or decreasing operations and relocating activities (Norley et al., 2008). The process of restructuring covers changes in execution, marketing, finance and services. Production restructuring, cost and performance improvement can be achieved by outsourcing skills and services to specialised firms. Hiring local talents and training them to meet the requirements also become a part of functional restructuring (Gurkov, 2009). Laying off excess staff and training in useful aptitudes can empower an effective functional restructuring if it is combined with a fundamental plan to accommodate most part of the layers of the old structure (Geroski and Gregg, 1994).

Investment Strategy

This strategy includes spending on diversification and innovation (Rumelt, 2009). This strategy is implemented by organisations who see recession as a chance to invest, innovate and enter new markets to get a competitive advantage. Many prominent companies took this advantage and launched successful businesses during a recession (Norley et al., 2008). Similarly, developers can consider purchasing properties and acquiring smaller companies during a recession. Potential alternatives for new development activities as suggested by Banerji et al. (2009) are expanding in developing markets, investing in innovation and spending on individuals/talents and acquisitions. It is evident from previous recessions

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that developers have gained an advantage by developing innovative structures, facilities and advanced business models by expanding into different markets (Norley et al., 2008). Investment strategies need assets, funds, administrative capabilities and technical expertise to implement them (Rumelt, 2009). However, such techniques are unsafe and most organisations are probably going to be occupied with short-term strategies, making it is impossible to consider innovation and development (Steven, 1998).

Ambidextrous strategy

This strategy is a combination of investment and retrenchment. It is vital for organisations to maintain a balance between exploration and exploitation for long-term success. Exploitation involves with the process of refining and extending the current capabilities, technologies and model whereas exploration includes testing and discovering new alternatives (Raisch and Birkinshaw, 2008). Ambidextrous companies integrate incremental development with intermittent change or utilisation of available resources to increase their efficiency and exploring different resources with competitive advantage and innovation (He and Wong, 2009). If firms adopt cost-cutting measures alone, they could be incapable to take benefit when the market situation improves (Raisch et al., 2009). There are three strategies to manage and achieve organisational ambidexterity such as structural, sequential and contextual. When structural ambidexterity is used in a company exploitation and exploration activities will be divided into separate divisions for each activity to enable differentiation between tasks (Lantham, 2009). Difficulty in integrating different groups and cost become main obstacles in applying this strategy in a development firm (Raisch and Birkinshaw, 2008). In sequential ambidexterity strategy, exploration and exploitation activities are undertaken in the same unit and same people but at different periods (He and Wong, 2009). This strategy is suitable for companies/projects with fewer resources since separation of one unit into smaller ones can be costly to undertake and manage (Eriksson, 2012). In contextual ambidexterity strategy, exploration and exploitation is executed in the same unit simultaneously (He and Wong, 2009). However, the level of ambidexterity depends on the culture of the organisation.

THE PROPOSED CONCEPTUAL FRAMEWORK

Industrial context, market conditions and the level of government support will influence the process of selecting a suitable strategy for organisations to survive in a recession (Grusky et al., 2011; O'Gorman, 2006). The company's resources and capabilities can be utilised to achieve better operational efficiency and the dynamic capability can be used to explore new markets and opportunities. These strategies can be executed using a range of income generating and efficiency-improving measures. The

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performance outcomes of these strategies can be measured through indicators like sales, profit and market performance as shown in the following diagram.

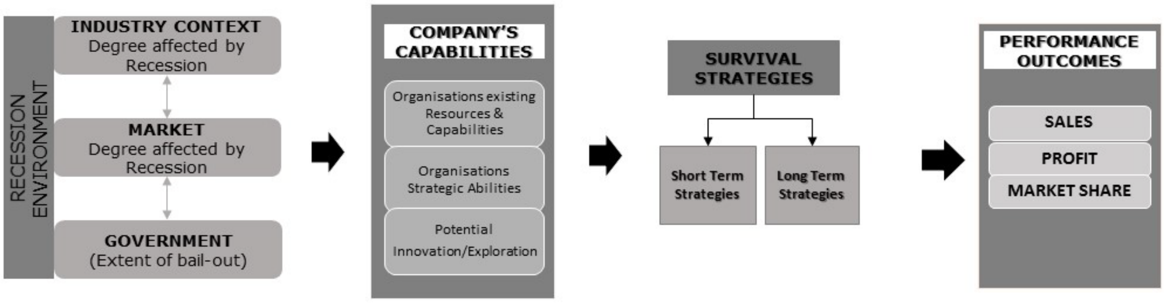

Figure 2 Systematic Framework

The framework related to the short-term and long-term strategies is presented in figure 3. This framework summarises the key strategies and measures identified and discussed in this paper. The advantages and disadvantages in implementing each strategy is also included in the framework. This will help developers to select an appropriate strategy depending on their circumstances.

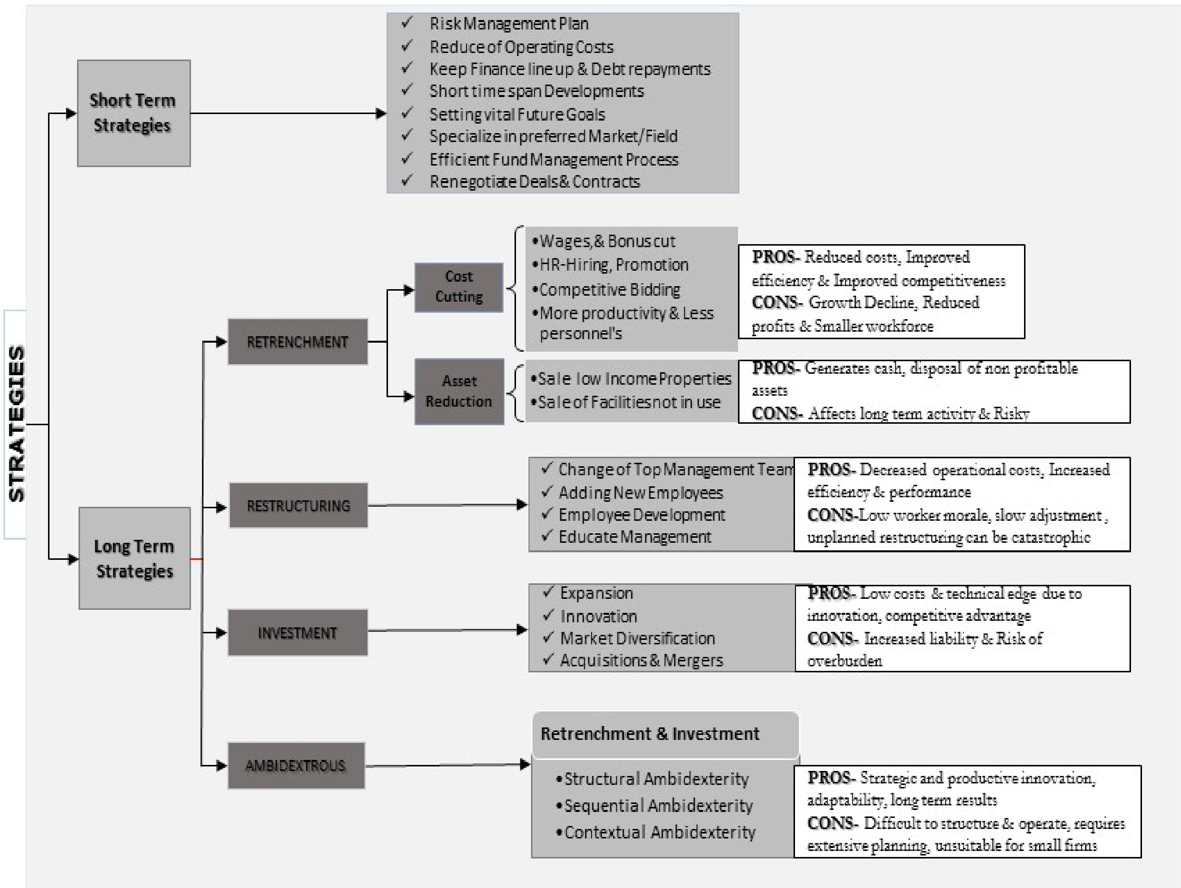

Figure 3 Framework to implement survival strategies in a recession

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CONCLUSIONS

Recession has several negative effects on the economy such as high interest rates, credit reduction, unemployment, low demands, low production and low profits, drop in resources, high competition and fall in share trading. However, the effective survival strategies that can be implemented in recession are more likely to be context specific and can be varied on industrial and geographical conditions. Thus, the aim of the research was to develop a framework that can be used by property developers to find out the suitable strategy to survive in a recession. The initial strategies embraced at the outbreak of recession are reduction in working expenses and overheads. After that it is necessary to use administration techniques to identify the most suitable strategies for survival. However, there is no single technique that assures survival or success of the business during a recession. The evidence available offers no consensus in the matter of whether retrenchment, restructuring, investment or ambidextrous strategies are more likely help property developers to survival in a recession. According to the literature, the ambidextrous strategy combines judicious cost cutting measures with equally carefully chosen investment activities to increase sales, margin and market share. However, decline in available resources, market and other factors are likely to prevent their adaptation in firms. Thus, it becomes extremely important for businesses to analyse the key factors, which influence their performance in a recession. Similarly, in order to successfully adapt these strategies it is necessary to understand the internal and external factors that allow or limit their adaptation to the crisis. Thus, it is recommended for organisations to monitor their business cycles closely to adapt different business strategies during a recession. However, it is necessary to conduct further research studies to understand the relationship between these survival strategies and their effectiveness in a recession.

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"IF YOU CANNOT MEASURE IT, YOU CANNOT CONTROL IT" - BUILDABILITY AND PERFORMANCE-BASED APPRAISAL

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ABSTRACT

Buildability has been a perennial issue in the Architecture, Engineering and Construction (AEC) industry, with advocates arguing for positive benefits related to cost, time, quality and safety in project development. Evidently, buildability has been seen to offer broader industry gains and efficiencies, and its assessment has been encouraged as a criterion in the regulatory approval process of some countries. If buildability offers positive outcomes in project development, how can these be introduced, measured and assessed in the project development process? In the absence of mandated buildability appraisal systems, does the industry develop its market mechanism to leverage the gains that its consideration offers? Detailed coverage is systematically reviewed with the aim to identify the current trends in buildability. Based on a comparative analysis of existing assessment models of buildability, this paper reviews the suitability of this model, by highlighting the potential difficulties of its adoption, against the current deregulated and highly performance-based context of the Australian construction industry. The outcome of this paper is to provide a research methodology to develop a buildability assessment tool for Australia.

Keywords: Australia, Buildability, Construction Practice, Deregulation, Performance-based design.

INTRODUCTION

Buildability has been a perennial issue in the Architecture, Engineering, and Construction (AEC) industry, since the 1970s. The use of the term has increased in part due to the perception of confrontational attitudes between client, consultants and contractors (Naoum and Egbu 2015). Several approaches have been developed to identify different components of buildability from pre-project planning to the disposing phases of a

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building or building system. In addition, productivity, cost and sustainability performance have been added as indicators to measure buildability. However, the difficulty of developing objective criteria remains as one of the biggest hurdles for the wider application of buildability practice. If buildability offers positive outcomes in project development, how can it be introduced, measured and assessed in the project development process? In the absence of mandated buildability appraisal systems, does the industry develop internal market mechanisms to leverage the gains offered by buildability consideration? Using a comparative analysis of existing models of interpretation of buildability this paper reviews the suitability of this approach against the current deregulated and highly performance-based context of the Australian construction industry.

BUILDABILITY – CONCEPT AND MEASUREMENT

Reportedly, the term buildability was initiated in the UK and constructability in the US in the 1960s, though with a narrowness in scope in being confined to the design process (Bambang 2006; Wong et al. 2007; Zhong and Wu 2015). Both terms are used to illustrate the improvement in AEC industry performance. In general, buildability is used as a full word to explain efficiency in the whole process, and constructability related to the construction processes and means and methods for the construction phase (Kuo and Wium 2014; Wong et al. 2006). According to Douglas (2008), buildability is one of the key focuses in a constructability review. Wong et al. (2007) concluded that despite the different interpretations of buildability and constructability, the design stage is said to be the critical phase in the implementation of buildability and constructability. For the identification of criteria for buildability, different authors propose various methodologies in its application. These range from initial idea/concept, type and characteristics of a project, business model, country, location, access, legal requirements, the experience of the owner, consultant design team qualifications, procurement methods for all stages, duration of the stages, contractors teams qualifications, utilisation, maintenance and disassembly. Indicators of performance across such criteria can be identified to measure global buildability of a project.

Some researchers, for example, Wong et al. (2007) have identified not only the issue of consensus of definition but also where along the project lifecycle should criteria be established. Overlaid with this is the changing and dynamic nature of potential indicator evaluation in the construction industry. These include mandates for sustainability (Brennan and Venigalla 2016; Zhong and Wu 2015), and safety (Yustisia 2014) in the construction sector. Other factors include procurement methods (Love et al. 2008; Naoum and Egbu 2015; Osipova and Eriksson 2011), developing technologies (Wang et al. 2016), and evolving construction means and

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methods (Kannan and Santhi 2013) requiring concurrent buildability measures.

BUILDABLE DESIGN SCORE – SINGAPORE’S EXPERIENCE

Buildable Design Appraisal System (DBAS)

A significant hurdle to the implementation of the buildability concept is the difficulty in measuring its tangible benefits to the construction industry. Researchers including Song and Chua (2006) and Jarkas (2015) highlighted that the construction industry still lacks methodologies for buildability measurement analysis. Pioneering in this area is the work undertaken by Singapore’s Building and Construction Authority (BCA 2005) which introduced the Buildable Design Appraisal System (BDAS) aiming to assess “the influence of design on site efficiency by means of calculating the buildable scores of the design”. Some researchers (Jarkas 2010) have argued that Singapore’s BDAS is the only tool available to quantify the effect of buildability on construction productivity. The BDAS was originally modelled after the Takenaka Corporation’s in-house buildability appraisal system (Poh and Chen 1998) and has undergone several iterations. The BDAS focuses on three main principles of buildable design, known as the 3S:

- Standardisation - repetition of grids, size of components and connection details
- Simplicity - uncomplicated building construction systems and installation details; and
- Single integrated elements - combining related components together into a single element that can be prefabricated and installed on site.

The appraisal system computes the buildable score of a design from three areas, namely the structural system, the wall systems, and other design features. As these account for a major proportion of site labour used in a project, it is considered that such an appraisal system is a useful tool in assessing buildability. In addition, bonus points are obtainable for these three parts for the use of productive technologies available in the industry. Table 1 provides a detailed breakdown of Singapore’s Buildable Appraisal system.

- The buildable score of the structural system focuses on the complete structural system of a building: 45[Σ (AsxSs)] + Structural Bonus Points, where a range of labour-saving indices is set for the precast concrete system, structural steel system, cast in situ, and roof system. If various structural systems (As) are used for different areas of a building, the percentage covered by the structural system is used to multiply their corresponding labour saving index (Ss) to arrive at the score.

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• For the wall system, the method of computation is 45[Σ(LwxSw)] + C + Architectural Bonus Points. It is the percentage areas covered by the external and internal wall system (Lw) multiplied with the corresponding labour saving indices (Sw). Bonus points for labour-saving structural systems are obtainable but are subject to BCA's assessment.

• Other design considerations are assessed at the micro level (Poh and Chen 1998). Points are given for each labour saving method/design consideration adopted, up to a maximum of 10 points.

Table 1: Detailed breakdown of Singapore's buildable appraisal system

	Range of choices	**Mandatory components**	**Bonus**
Structural system (45%)	• Precast concrete system (ranging from full precast to precast of single component (i.e. slab) • Structural streel system • Cast in-situ system • Roof system (non-RC)	• Use of welded mesh for cast-in-situ concrete floor (>65%)	• Recommended precast joint types • Mechanical connection for precast column joints, beam joints, wall joints • Innovative structural steel connections • High strength concrete (>grade 70, at least 5%) • Self-compacting concrete (>30%) • Diaphragm wall
Wall system (45%)	• Dry wall • Curtain wall/glass partition/dry partition wall/prefabricated railing • Precast concrete wall • Lightweight concrete panel • Cast in-situ RC wall • Precision block wall • Brick wall/block wall	• Dry partition wall for all internal dry areas	• Design without high voids[1] • Design without complex form[2]
Other buildable design features (10%)	• 3 most common sized columns, beams, door structural openings and windows (Standardisation) • Repetition of floor-to-floor height, structural floor layout (vertical) and horizontal grids • Multi-tier precast columns, precast meter chambers, Prefabricated MEP risers, No screeding for any flooring, single	• Typical stories standardized to either 2.8m, 2.975m, 3.15m, 3.3m, 3.5m, or 3.6m height	**Finishes & Dry Construction** • Drywall for party wall, wet areas • Engineered timber flooring • Carpet, vinyl and raised floor • Engineered stone flooring finishes **Mechanical, Electrical and Plumbing (MEP)** • Prefabricated and pre-insulated duct for air-

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	floor level without drops/kerbs within apartment unit **Single Integrated Components** • Prefabricated bathroom units • Prefabricated household shelter • Precast external wall with cast-in windows		conditioning system • Flexible pinker dropper • Flexible water pipes • Common M&E bracket **Modern Construction Systems** • Prefabricated prefinished volumetric construction (PPVC) • Engineered Timber (CLT)
[1] High voids refers to heights that are more than 9m. Different percentage of high void is given different bonus points, the less percentage, and the more points to be given. [2] Complex forms refer to building façades that are tilted, tapered, twisted or of free form. A design that does not have complex form will get a maximum of 3 points.			

Note: each element (items in the Bonus excluded) from the above has its correspondent's labour saving index)

(Source: Adapted from BCA (2015))

BDAS on productivity, cost and sustainability

Productivity

Contractors in Singapore are required to operate a biometric authentication system at their project site to collect construction productivity data of the building works. Such data is used to assess the productivity level of the construction work. An early study was undertaken by Poh and Chen (1998) in which empirical results from 37 completed building projects in Singapore provide strong support that a larger buildable score results in greater labour efficiency, and higher site labour productivity. In the residential sector, a significant linear correlation between labour productivity and the buildable score is observed. Similarly, Low (2001) showed positive relationships between buildability, structural quality and productivity.

Such correlative support of the impact on buildability and productivity suggests that effective measuring mechanisms can be of benefit in the early design stages of a project. In Australia, with its performance-based regulatory approach where design resolution is transferred to the market, tangible productivity gains may be garnered with the adoption of effective buildability measures that may inform design choices. Furthermore, Australia has embraced building procurement systems that integrate design and delivery into a single package. This procurement approach with its single-point of responsibility may be leveraged via authentication data that brings together design decisions and efficient construction and labour management processes. Constructability research which investigates performance-based regulatory regimes and a broader range

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of project delivery mechanisms and the influence of such factors on the applicability of measures, however, remains largely absent.

Cost

In Poh and Chen's (1998) research, no distinct trends are indicating a significant relationship between construction unit costs and the buildability score. Three possible reasons were offered (Poh and Chen 1998):

1) The buildability appraisal system is concerned mainly with a building's structural system without taking the external wall design and the use of less labour-consuming elements into account;

2) The buildability score indices are fairly fixed for each design scheme regardless of the project's category, scale, number of storeys, quality of workmanship, and market conditions;

3) Other factors may have a greater impact on costs, such as contractor's management style and experience, weather and site conditions, as well as costs of labour and materials.

Sustainability

In 2006 Australia embraced requirements for energy efficiency under its building regulations for all building classifications. This, coupled with increasing adoption of the non-regulatory Green Star rating system, introduced in 2003, for non-residential construction provides support for Australia's interest in the application of sustainability principles in the construction industry. Despite this, little empirical research has been done to map out the relationship between sustainability and buildability. Singhaputtangkul et al.'s (2013) work, is one of the few which have identified a list of criteria for achieving sustainability and buildability. However, it is limited to the assessment of building envelope design. Such paucity of research brings into question the limitations that have been applied to date in the discussions that have transpired on relevant criteria for buildability. Buildability measures that are only linked to labour and material construction efficiency run the risk of ignoring equally pressing considerations such as sustainability or generating conflicts between performance-based regulations in meeting sustainability targets which are seen as having commercial value as evidenced by the uptake of the non-regulatory Green Star rating system.

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BUILDABILITY RESEARCH IN AUSTRALIA

The buildability concept started in Australia in the latter periods of the 1980s and 90s (Francis 1994; Hon 1989), in a first approach directed to project management activity. Extended later (Hyde 1995) to the relationship of buildability to architectural design and developed further to integrate design with construction (Griffith and Sidwell 1997). Buildability was defined as a concept that focuses on the influence of design and its impact on ease of construction. And, constructability was defined as a concept that takes a more holistic perspective of all stages in the total building process.

The concept of buildability (constructability for design phase) in Australia was analysed by the Construction Industry Institute (CIIA, Australia) identifying twelve buildability issues, commencing with the concept of design and construction integration and finishing with the need for feedback mechanisms to verify buildability decision making. This approach resulted in several publications (Crowther 2002; Francis 1999) which looked at a whole of life process from concept stage until deconstruction consequences for buildability.

More recently research has been undertaken focusing on the impact of procurement methods to improve buildability. Early Contractor Involvement (Cintra 2005), for example, is seen as offering advantages against traditional construct only. The ECI process provides feedback from tenderers at the beginning of the process delivery management (PDM) until deconstruction. Design consultants can resolve ambiguities, discrepancies, and buildability issues and continuous design improvement in an early stage (Mashiah 2008). New research initiatives at the academic level have been developed to increase profession's relationship with both "ideas of making" and the "making of ideas".

FUTHER RESEARCH AND METHODOLOGY

This research in buildability has a potential to be a future research that has the aim to determine the best practices on buildability assessment tools and the level of applicability of successful existing tools for the Australian construction industry. Furthermore, in a performance-based regulatory system, the construction industry in Australia is predicated on a market determination of efficient solutions. It makes fertile ground for further research, should accurate measures of buildability measurements be developed to verify one of the major premises to support buildability as a cost mitigating tool in deregulated markets that have embraced alternative procurement systems. The proposed methodology will be using a sample, recruited with the help of Australian construction companies. Data will be collected using a self-administered questionnaire, based on Singapore's BDAS system, and sent to 100 design professionals working in that activity for more than 5 years. The results will be used to prepare the foundations for a new system to measure level of buildability of the design in the Australian construction industry.

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CONCLUSIONS

The concept of buildability has been discussed largely on the last few decades. Singapore's buildable appraisal system, is a unique existing system which has developed some criteria to measure buildability and addresses buildability primarily as a construction system approach. It computes the extent to which the principles of standardisation, simplification, and single integrated elements are found (BCA 2015). This paper explored that such factors are not of themselves sufficient measures of buildability. In a permutation of an aphorism attributed to Peter Drucker, *if you cannot measure it, you cannot control it*, criteria for measurement in order to have a mechanism of verification, control and improvement is essential. Due to the broad meaning of the term, it is important to understand the different criteria that can be applied to measure buildability. The systematic review done in this research identified some authors that deal with buildability as a concept, others as a method and others as a process. However, clarification of what is important and where such parameters should apply in meeting project objectives and delivery is essential to make the analysis of the results compatible to the goals.

This research will provide a better understanding of the concept and applicability of Singapore's solution in Australian market. This will be great impact of the construction industry and the assessment of construction projects in the design stage helping to measure their performance to be managed to the desired level of productivity, cost and sustainability.

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AN INVESTIGATION OF DIGITAL AND ONLINE INFORMATION TECHNOLOGY ADOPTION IN PROPERTY MANAGEMENT

ABSTRACT

Recently, driven by the pressure to improve efficiency and sharing information, there is growing interest to introduce digital technologies into the property management market. Emerging digital information technologies are changing the way of managing rent, purchase and sale of properties as well as real estates' business. The technology covers a wide range of items such as professional web-based platforms and social media offering rich information to customers. Despite the proven advantages of sharing information through visualization and query making options, and drilling into the digital documents, the factors influencing the acceptance of such technologies by customers and real estates has not been fully studied. This paper aims to develop an innovative technology acceptance model identifying influential key factors of acceptance of the technologies by both customers and real estate agencies. A survey of 50 real estates' staff members and their customers is conducted. The results indicate that the number of agencies and customers tending to use information technology and online data bases as their main resources is increasing.

The results of the survey show that real state agencies believe that the use of online information technologies enhances the number of customers as increases the level of visibility and accessibility of their services. Customers believe that factors such as better delivering and on-time services are main contributors of making the right choice to rent or purchase properties. Increased speed of transactions, reduced time for finding an appropriate property and provided capability of comparison with similar properties are found to be main advantages of these online information technologies.

The results of the survey also show that the main problems of technology adoption from real estate's point of view are lack of real estate agents' knowledge and shortage of specialists. In addition, the most significant barriers of technology adoption in the real estate industry are lack of trust to companies' websites and also lack of knowledge for users.

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Keywords: Digital Information Technology, Property Management, Real Estate.

INTRODUCTION

Information technology (IT) including different versions of websites, virtual reality tools and digital communication are increasingly becoming a major requirement for business (Najib Razali, Manaf et al. 2010). Real estate business is rapidly changing due to high demand of sharing information with customers who are living in different countries. Current studies show that developing countries such as China and Malaysia are undergoing radical changes by shifting from traditional based business to an online web-based communication channel attracting thousands visitors from their real estate cases annually (Wang and Lv 2013). The survey of National Association of Realtors in 2014 indicates that new home buyers prefer to use virtual options and place emphasis on virtual tours and videos showcasing properties and neighbourhood's area.

The survey of National Association of Realtors conducted in the US represents a sample of home buyers who purchased a primary home from July 2015 to June 2016. The statistics show that:

- The initial action of 44% of buyers was to look online at properties for sale and only 17% of buyers first contacted a real estate agency.
- 79% of property buyers responded that their source including their real estate web has been useful.
- Interestingly, 89% of the new home shoppers use a mobile search engine at the onset and throughout their research.

Currently the number of people who find a home through the internet is increasing (Ho, Chang et al. 2015) because not only does it give a better corporate image but also it can be used as a marketing tool, giving wide coverage to reach potential client, better and quick information gathering and one of the cheapest way to sell the products (Najib Razali, Manaf et al. 2010). The internet has the potential to give a better image of the company, real estate and properties and plays a crucial role as a marketing tool in property management. The advantages of the internet as a marketing tool are giving wide coverage to reach potential client, better and quick information gathering, as well as being one of the cheapest way to sell the products (Najib Razali, Manaf et al. 2010).

A large number of real estate agencies are investing in this virtual world and use the web as a primary means to communicate with customers and to build their businesses. For instance, companies such as Trulia, Redefine and Zillow have distinguished the role and benefits of innovative technology in real estate industry. They have already utilised technology to change user behaviour from being dependent on realtors to being dependent on internet (Chiu 2016). The survey of National Association of Realtors in the US in 2016 shows that internet is the most important source in the home search process for 89 percent of home buyers. Online

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website research continues to be the first step that most buyers choose, and Real estate agencies remain a vital part of the home search process, and are the second most frequently used information source for home buyers. This connection between real estate agency and internet, social medias, technology devices such as 3D scanning camera and the practices of using internet in traditional real estate brokerage encourage into the development strategies (Hin Li and Wang 2006). Real estate agents store information in their data bases that buyers look for in website such as floor plans, site plans, local property price information, buying guides, financing and legal guides, location maps, pictures or concepts, area information. In Figure 1 Webpages of two selected real estate agencies in Tehran show some of these features.

a) A screenshot of a property searching page that helps to choose the desired area.
Source: http://www.moshaverin.com/

b) A screenshot of comparison among property options in terms of price and location.

Figure 1 Webpages of two selected real estate agencies.

Another important aspect of the real estate webpages is the content that they provide to customers. Table 1 shows that the main information types that currently are presented in the webpages are physical attributes such as plans, façade and financial attributes. However, there are missed information such as comparing each room areas, light, moisture, health and safety conditions, energy usage estimations comparing to other selected properties by the customers.

The industry reports show that the increased use of internet usage and information technology have a drastic and negative effect on the real estate market in terms of both decrease of revenues and jobs (Muhanna and Wolf 2002). However, there are barriers shift from traditional business to wide use of digital technology adaption in property management particularly in developing countries. For example, previous studies shows that lack of education, downsizing of jobs, data corruption, the gaps in legislation in terms of security and standardization are main barriers of real estate technology adoption (Sun and Ifeanyi 2014).

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Table 1 The information that buyers look for when browsing

Types of Information	Potential features
Floor plans/ site plans	Number of beds, measurements, overall size of the building, garden face
Local property price Information	evaluating prices
Buying guides	getting familiar with process of selling/buying proper, managing time/cost, suitable for first buyers
Financing and legal guides	Getting with the potential options get an idea of what your monthly mortgage payments; Being aware of taxes and home insurance and additional costs
Location maps	Access, neighborhood
Picture	Giving a big picture of the property
Virtual tours and 3D walkthroughs	Time saving, instant preview of the properties, saving energy and money specially when looking for homes out of town, get family and friends opinion of the property, investigating the house from anywhere with internet access
Area Information	Exploring the location, neighboring areas, access, convenience
Internal/ External imagery	Getting the style/design of the property
Building features	accelerating the search based on expectation property/style/design/examination age of the building

Chinese companies, for example, have difficulties to apply e-business as a result of the unpredictability and uncontrollability of all the uncertain factors in internet environment. Therefore, many real estate managers can not completely take advantage of e-business (Wang and Lv 2013). In addition, it is expected large amount of job losses are in real estate business, including sales agencies and developers (Muhanna and Wolf 2002). Table 2 presents the characteristics of traditional real estate method and modern real estate methods globally.

Table 2. Characteristics of traditional and modern real estate methods

The type of real estate method	Traditional real estate procedure/method	Modern real estate (method procedure/method)
Example of current technologies	An offline software program to save properties information	Network based webs such as Domain.com.au
Available properties	The list of properties is limited to only area of agents that clients refer to.	A search option is available on their web to find properties in desired area.
Location based information	Doesn't offer client's any location based information using digital technologies.	Use Google Maps such as local services (schools, hospitals, parks), crime rates and boundaries.

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Simple and Advanced search of properties	The system is not available for the customer and manually should be updated.	The data bank automatically can be updated and available to owners, agencies and customers.

Digital technology is available to be used in the property market, but still new applications of the technology should be explored. The literature in this area is scarce. There is lack of understanding in adopting digital technologies in real estate agents' business (Manyika, Chui et al. 2013). A new concept in the field of digital technology is virtual reality (VR) that refers to any computer-generated simulation of specific parts of an environment or real activities in 3D images (Brenner 2017). VR assist customers to realize the real-place experience and experience human-computer interactions (Kun and Zong 2009). Virtual reality was used in conjunction with other tools such as 3D gaming, Facebook, Google and Microsoft, investing in VR technology, have reached the considerable success in terms of developing VR technology (Warburton 2016). In the real estate industry virtual reality (VR) has the potential to be used as a tool to help prospective homebuyers tour homes to immerse themselves in the space (Brenner 2017). Therefore, a number of real estate agencies stand to use the advantages of this innovative technology (Warburton 2016). HouseLens and Matterport (2017) are VR leading companies in real estate space, which provide visual marketing solution to help realtors to grow their business. They are good examples of companies which use VR to control the power of visual marketing, which is led to faster sale times and increase in sale prices (Brenner 2017).

Based on the Goldman Sachs (2017) research, it is estimated that the VR and AR market in real estate industry will reach $2.6 billion by 2025. In terms of consumers, VR will have the role of guiding buyers and sellers who make decisions to buy homes. VR has the potential to overcome some barriers such as time, distance, as well as money limiting buyers from making decisions for buying a home (Brenner 2017). In addition, residential and commercial realtors may take advantage from having potential tenants who are able to walk through of a three-dimensional render of the space, by using a custom application from a remote distance (Warburton 2016). Table 3 presents a summary of previous studies focusing on the application of digital technologies in real estate business.

Table 3 A review of the application of digital technologies in real estate business

Focus of the paper and objectives (reference)	Method and sample size	Finding	Limitation

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To developed business strategy and evaluate the internet usage in Asia (Najib Razali, Manaf et al. 2010)	Secondary data set from web sites of 30 property agencies.	Asian companies score 10 out of 15 for internet business strategy on average.	Small sample size that cannot give an idea about the whole industry.
To explore proper strategies for e-commerce residential real estate (Dorwart 2016).	Descriptive qualitative research based on interview from online organizations in western Nebraska.	The usage percentage: Zillow (67%), Realtor (67%), Facebook (50%), Professional or Firm Website (100%) The usage of the internet, mobile and social media coverage help real estate organizations to stay profitable	Different experience level of interviewees in real estate business.
To improve the service quality and increase the performance of real estate agencies (Sun and Ifeanyi 2014).	Interviewing: 10 e-platform service users and 20 website owners. China.	Search Engine Optimization, Personalization and Priority Option are suggested to provide reliable services for customer.	Doesn't cover customer's points of view to have the complete picture of real estate sector.

The critical review shows that the current literature investigates the problems faced by real estate agents. This type of studies mainly tends to identify the challenges of traditional business model. Another type of studies focuses how they can develop the current technologies to attract more web-visitors. However, there are few studies that tend to facilitate the technology adoption rate in the property management field. This is a gap in the literature to identify key factors to measure the customers' perceptions towards using a modern technology. This paper aims to fill this gap through identification of key factors affecting technology acceptance in the real estate business. The findings of this study would be useful for real estate agencies to predict users' perceptions and behaviour towards digital options of their webpages, and to develop new strategies such as upgrading the e-commerce websites in order to maintain the business and still remain profitable. Additionally, this study integrates two theoretical approaches: the technology acceptance model and technology readiness concepts.

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RESEARCH METHOD

As stated in the previous section, the purpose of the paper is to identify key factors influencing customers' perception of using digital technologies for property businesses. To do so, a questionnaire designed which is divided into two main sections. Section A includes questions about the participants' background, and Section B includes instrumental questions to measure the users' perceptions of using a specific digital technology. A total number of 50 participants randomly were selected from real estate agents and their customers in Tehran. Table 4 shows the participants profile. A structural model equation (SME) and regression analysis techniques were utilised to analyse the data. Multivariate data analysis is used since it is known as a powerful method of structural equation modelling. Partial least squares (PLS) regression is a relatively new method of structural equation. This method is used both for simple and multivariate regression with multiple dependent variables. PLS is based on the lowest square for optimizing the variance in the dependent structures of structural equation models. Unlike structural equation, covariance modelling assesses the amount of fitness of the assumed model.

Table 4 Participants profile

Measure	Item	Frequency	%
Age	20-30	7	14
	31-40	24	48
	41-50	12	24
	Above 50	7	14
Education	Senior high School	33	66
	Undergraduate	17	34
Experience in real estate	Below 10 Years	22	44
	10-20 Years	24	48
	More than 20 Years	4	8
Total	50		

RESULTS

The survey shows that 42.7% of respondents believe that they currently receive the property price information rather than other types of information, and 29.2% of the respondents expressed that, the main change which technology has brought to real estate industry is to receive more accurate information about the property.

The analysis shows that the key benefit of the technology is the way of collecting and delivering data. In contrast, the main inhibiting factors behind technology adoption (e.g. websites, social media, latest innovations) in the real estate industry are lack of specialists and the shortage of real estate agents' knowledge. From customers' point of view, the most significant inhibiting factor behind technology adoption in the real estate industry is the lack of trust to companies' website, and the second most vital factor is the lack of knowledge for user.

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The analysis also shows that 58% of respondents believe that the implication of technology in real estate industry has little influence on information monopoly. In addition, 74% of surveyed realtors believe that technology has the significant impact on the process of selling or buying a house. Furthermore, 82% of participants report that few traditional real estate agents can seize the customers first in the provision of many central and related real estate services as a settlement services provider. Finally, more than 58% of respondents believe that the possibility of technology expansion for all the real estate agencies is high and very high.

Given that the appropriate value is 0.7 for Cronbach alpha (Cronbach 1951), 0.7 for composite reliability (Nunnally 1978) and 0.5 for AVE (Fornell and Larcker 1981). Table 5 shows that all these criteria have a suitable amount in relation to latent variables, and the reliability and convergent validity of the model can be confirmed. In order to, check the divergent validity of the model, the amount of correlation of each construct with its indices was compared with the correlation of that construct with others. Figure 2 illustrates the path coefficient and the explained variance for each latent variable by the corresponding items. All items could explain over 40% of the variance.

Table 5 Convergent validity analysis, Cronbach alpha, composite reliability

Factor	Coefficient of Cronbach alpha (Alpha>0.7)	Coefficient of composite reliability (CR>0.7)	Coefficient of convergent validity (AVE>0.5)
Expected performance	0.800	0.862	0.556
Expected effort	0.861	0.900	0.646
Ease of use	0.777	0.897	o.814
Usefulness	0.903	0.926	0.675
Output quality	0.791	0.864	0.614
Investment	0.779	0.856	0.598
Facilitating conditions	0.800	0.881	0.713
Behavioural intention	0.917	0.947	0.857
Effect of technology	0.852	0.900	0.692
All factors	0.959	0.962	0.556

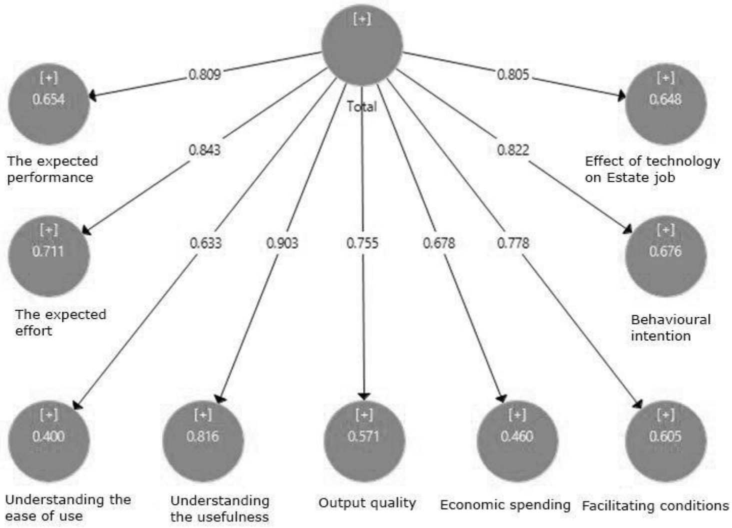

Figure 2 the path coefficient and explained variance of SME

Table 6 shows the results related to the model structure. The table indicates R^2 and F^2 values and the significance level of the path coefficients for each scale in the structural model of the study. The results showed that F2 values for each scale was more than 0.15 and the path coefficient of each scale is significant ($P<0.05$). The coefficient of determination values of R^2 for the dependent variables (factors) in the models are 0.654, 0.711, 0.400, 0.816, 0.571, 0.460, 0.605, 0.676 and 0.648, respectively. According to Davari (2014), an appropriate criterion for the amount is higher than 0.15. These three indices can confirm the appropriacy of the measurement in the model structure. Therefore, the constructs have appropriate validity.

Table 6 R^2 and F^2 values and path coefficient in the model structure

Dependent variable	R^2	F^2	Path coefficient	Sig.
The expected performance	0.654	1.888	0.809	0.001
The expected effort	0.711	2.461	0.843	0.001
Perceived ease of use	0.400	0.668	0.633	0.001
Perceived usefulness	0.816	4.423	0.903	0.001
Output quality	0.571	1.329	0.755	0.001
Economic spending	0.460	0.853	0.678	0.001
Facilitating conditions	0.605	1.532	0.778	0.001
Behavioural intention	0.676	2.088	0.822	0.001
Effect of technology on Estate job	0.648	1.844	0.805	0.001

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Conclusion

While previous studies develop modern technologies for property management, less attention has been paid to the process of technology adoption including usefulness and ease of use. This paper aimed to identify main factors contributing in the real estate technology adoption process. An intensive literature was reviewed to propose factors influencing the users' decisions to use a new technology for property management purposes. The factors are used as constructs of a model including expected performance, expected effort, ease of use, usefulness, output quality, investment, facilitating conditions, behavioural intention, and effect of technology on task. A survey is conducted to explore the participants' intention towards technology adoption. The authors found that key factors affecting technology acceptance in the real estate business are delivering better and accurate services to applicants who are contributed to make the right choice to buy properties. This results in increasing the speed of transactions, reducing the time of purchasing and comparability with similar properties in real estate industry. It is also found that using internet enhances the number of customers by delivering better and accurate services to applicants who are contributed to make the right choice to buy properties. This results in increasing the speed of transactions, reducing the time of purchasing and comparability with the same property in real estate industry.

This paper contributes to the body of knowledge by developing an initial model for information technology acceptance in the field of property management. The future study should examine the model in different contexts using more participants.

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CRITICAL REVIEW OF FACTORS AFFECTING THE QUALITY OF BUILD IN RESIDENTIAL VOLUME BUILDING

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ABSTRACT

Consumer satisfaction is no longer a novel concept in terms of quality assurance and is paramount for business survival, success, and economic prosperity. It now forms an integral part of most business practices. The ability of the construction industry to deliver a quality service is critical for sustained consumer confidence and a healthy economic performance. In recent years, consumer satisfaction has been shown to form a key driver for continuous business improvement particularly in the residential volume building sector. This is a working paper and is part of a major review on the ability of the volume building residential industry in te state of Victoria to deliver quality services to their consumers. The outcomes of this on-going research project will provide both academics and practitioners with valuable support in this direction. This paper presents the initial findings based upon one of the author's experience in the volume building sector. The findings suggest that there are several factors that directly and indirectly influence the housing quality in Victoria, these include: demand and supply of housing; marketing; sales through to site completion; building inspections and audits; supply chain relationships; competency of site supervisors; project planning and control; after sales service within which the residential sector operates. These factors have varying influences on each other, and are therefore interrelated and cannot be treated in isolation.

Keywords: consumer satisfaction, quality, residential building, volume builders

INTRODUCTION

The performance of the housing sector is a key indicator in the health of the Australian economy. The Construction Industry typically represents 8.5% of the economy's GDP (Australian Bureau of Statistics (ABS), 2015) and is the third largest employing industry in Australia, employing approximately 1.05 million people, or around 9% of all Australian workers (ABS, 2015).

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Demand for housing

The Victorian Building Authority (VBA) reported Victorian building permits' value increased to $31.5 billion in 2016, which is 12.3 per cent higher than the record of $28 billion set in 2014-15. The Victorian population growth of 1.8% (101,521 people) made it the fastest growing state in the country with a net inflow of interstate migration increasing by 24% in 2015 (HIA, 2015). This is a key factor influencing the demand for housing. The National Housing Supply Council (NHSC) (2013) projected a net increase of 3.3 million households in the 20 years from 2010 to accommodate the growing population.

Consumer satisfaction

Consumer satisfaction is defined as "the number of consumers or percentage of total consumers, whose reported experience with a firm, its products, or its services (ratings) exceeds specified satisfaction goals" (Farris, 2006). Collection of this type of data has been tried and tested in the marketing sector for years as it has proven to provide a solid indication of consumers' intentions and loyalties. It also not only provides an indicator of how a business is performing, but is able to provide an indication of whether consumers will return or not (Farris, 2006).

In the volume building sector, there is a notion that consumers are more concerned with price and product over and above receiving a good level of service from their builder, whereby the 'satisfaction' is achieved when they attain their goal of getting the best value versus size of home available amongst the volume building market. Research has found that in fact one of the main factors driving consumers' choice of builder is service quality; and that their level of satisfaction tends to relate more to the positive and negative experiences during construction over and above any other reason (Forsythe, 2016). Often new consumers' choice of builder will be driven by recommendations by friends or family (word of mouth); or they will rely on research undertaken on product review platforms. Willingness to recommend a builder is a key metric that is directly related to consumer satisfaction (Farris, 2006). The ability of the construction industry to deliver a quality service is reflective of sustained consumer confidence and a healthy economic performance. In recent years, consumer satisfaction and feedback has become a key driver for continuous business improvement particularly within the volume housing sector. This is not just focused at existing consumers, but also at new and prospective consumers and the service they receive through the sales, operations, construction and maintenance process.

Process for volume building

Volume housing is based on a product being designed and delivered 'en masse', and is seen to be critical to the overall Victorian housing market due not only to its scale, but also its ability to use this scale to deliver more affordability to the housing market, in particular in land growth

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areas (Keane and Birrell, 2010). Volume builders deliver significant numbers of dwellings in the general housing market, with the larger branded companies accounting for the largest share of this provision. In the last ten years approximately 40 per cent of all new dwellings were delivered by the largest 100 construction companies (HIA, 2016).

For consumers, the construction or renovation of their home is often the largest investment in their lifetime, however many are not equipped to deal with problems that may manifest. In a recent Australian Consumer Survey report, almost one in three residential building consumers reported experiencing a problem, predominately related to poor building quality and workmanship (VAGO, 2015).

METHODOLOGY

There are many factors that contribute to quality in the process of volume building. The following critical analysis is based upon reflections on the experience of one of the authors, an architect who has worked as a builder in the domestic sector for over 15 years and was employed by two of Victoria's largest volume builders for two of those years. This analysis of the factors which contribute to the lack of quality in volume building is supported by references to both the academic and industry-based grey literature.

RESULTS

Analysis of factors contributing to the lack of quality in volume building

Critical reflection revealed there are seven main facets of the volume building process where quality can be compromised: the marketing and selling phase; the process of sales through to completion; building inspections and audits; supply chain relationships; site supervision; planning and scheduling; and after-sales service and warranty. These factors are now analysed in detail.

1. Marketing and selling dream homes

In the volume building sector, branding has been incorporated into the total perceived consumer experience to include slogans such as "Love where you live" (Metricon) and "There's no place like home" (Burbank). Web platforms are enticing to look at and user-friendly interactive, enabling potential consumers to 'build' their future home. The idea is to create a controlled pre-purchase expectation (Davidow and Uttal, 1989) through enabling potential consumers to experience a taster of products and inclusions available whereby the next step for the consumer is to experience the tangibility of the home at a display village. In volume building there is a deliberative process that centres on display houses being built in display villages for many reasons, but predominately for research and development purposes, and to use these homes as the focus

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of the companies' marketing strategies (Dalton et al., 2013). The display homes are set up to exhibit the optimum level of building specification and quality, decorated to entice consumers to feel as though this could one day be their home. In actual fact, what consumers are not made aware of is that the display homes' predominant purpose is to be the selling lever reliant on cajoling the sales transaction, then upgrading the basic home specification to match that of the display. Often the display home is not the 'standard' type of home and any amendments to achieve the display home finish could potentially significantly inflate the base price of the home (Consumer Affairs Victoria, 2017). What the consumer is also not told is that all measures are taken to ensure that the display home is completed to an exceptional standard at a pre-site and on-site operational level. The same level of detail and stringency is often not extended to the general mass building of homes, the effects of which have contributed to the general lowering of consumer satisfaction and confidence in residential building, and increased manifestation of problems around quality and workmanship.

2. The process of sales through to completion

The volume building process is made up of several key milestone baton changes that seek to translate the initial display home sales brief into a series of detailed documents that will enable the home to come to its fruition. The production process begins its life with the drafting team, whereby the sales brief is translated into a set of building documents. During this process the type of home selected is modified to suit the building site, any upgrades are included, and the Clients are sent to a colour appointment to select their fixtures and finishes palette. Once this process is complete, the documents are dissected into a bill of quantities (BOQ), purchase orders created, a major domestic building contract is entered into between both parties, and the documents are then submitted for building approval. Upon receipt of the building approval, the documents are collated into a site file for the construction team to mitigate. During the construction phase, the supervisor is responsible for calling up suppliers and trades and ensuring the build is in accordance with the contract documentation, as well as the regulatory framework (NCC, Regulations, and Australian Standards etc.). They typically rely on the accuracy of the documentation, and are required to complete quality assurance (QA) checks throughout the key construction milestones (typically at slab, frame, lockup, pre-plaster, and completion). Construction times vary, but on average, a single storey takes between 20-24 weeks to complete, whilst a double storey can take between 26 – 30 weeks to complete. During construction the consumer is in contact with their supervisor for technical queries, and a 'Consumer Service Officer' for administration and contract related queries. The process from sales to maintenance is quite onerous and relies heavily on each team performing their role correctly, whereby the baton change to the next team should not occur until this happens.

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Volume builders are measured and ranked by HIA and Cordell via the annual 'Housing 100 Report'. These rankings are based upon the number of monthly building permits received, and physical site starts, where all the pre-site operations teams' KPIs are driven by achieving/exceeding these measures. As a direct result of the monthly push, a majority of site files are produced which are defective or have omissions consequently affecting the construction process.

3. Building inspections and audits

In Victoria, private and local government building certifiers are the authority for ensuring building projects meet the minimal standard of specification required by the building codes and regulations. Privatization of this function occurred in the early 1990s. Over the past twenty years, the Victorian Building Authority (VBA) has found that approximately ten per cent of the privately registered certifiers have been formally reprimanded from being issued fines, to license suspensions, license limitations, and cancellations. Furthermore, the VAGO (2011) report found that the regulatory body set up to police the industry in Victoria, the VBA (Victorian Building Authority - formerly The Building Commission) was unable to consistently guarantee to consumers that the framework that existed for practitioner registration and regulation was free of flaws therefore offering consumers little assurance that domestic building was compliant to minimum standards (VAGO, 2011).

In Victoria there are restrictions on who is allowed to issue building permits. According to the Building Regulations, a Building Surveyors' role is 'to provide an independent overview of the design and construction process, and at completion of building works, to ensure that the building is safe, provides amenity, accessibility, and meets energy efficiency requirements' (VBA, 2015). During construction, the Building Surveyor is charged with completing mandatory inspections. These mandatory site audits ensure that the building is being constructed correctly and compliantly. Unfortunately, what is lacking is a further, more detailed independent auditing of the project as it progresses from frame to lockup (which is critical to ensure the correct finishing of the home). Many builders modify the design due to set out problems, design issues or to ensure that it works cosmetically. The Building Surveyor has already formally approved the frame, whereby any further adjustments at the builders' discretion will be hidden.

Building certification has become a lucrative business in the volume building sector. With the sheer quantity of homes built per annum, private building surveyors competitively vie for the business. So much so that it has become a cost cutting exercise amongst some of the larger building certifier providers. This fee cutting is based generally based upon the economies of scale; however, other aspects of their fees are affected as well. The inspections make up a large portion of the fee as it requires a

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licensed building inspector to attend site a minimum of three times per home (pre-slab, frame, final). In order to be commercially efficient, the inspectors are often told to 'streamline' their practices. The question is whether this 'streamlining 'is allowing the certifiers to adequately fulfil their duty of care to the consumer, and perhaps compromising the quality and integrity of the build?

4. Quality of supply chain relationships

A sub-contractor is commonly used in the building industry, whereby the sub-contractor is engaged by a head contractor to complete specialised works on site ranging from earthworks, concrete, carpentry, services, joinery etc. As much as 90% of building works on a project is carried out by a diversity of sub-contractors (Mohamed and Anumba, 2006). This means that the completion of the physical built form is heavily reliant upon the performance of the sub-contractors. In the volume sector, where supervisors are assigned anywhere between 12 – 24 single/double storey homes at any given time, and construction managers' are overseeing a team of between 6-8 supervisors, this means that site management is undertaken part time, and on a prioritisation of build stage process, with the teams' time split between the volume of homes. As a result, the team are often reliant upon the sub-contractors' performing their tasks competently under minimal supervision. However, minimal supervision could potentially lead to poor overall management of the project, lead to poor quality outcomes, late project delivery, and create dissatisfaction between the head contractor and sub-contractor, as well as with the consumers (Othman, 2007).

5. The competence of site supervisors

Site supervisors are critical to each projects' success (Ling and Tan, 2015). The site supervisor's job is to translate the documentation into a series of interrelated tasks and call ups for out sourcing subcontractors and suppliers. A typical portfolio of projects for a volume building site supervisor is anywhere between 12 – 24 single/double storey homes at any given time. The impetus is to deliver the homes within compressed time frames, whilst swiftly meeting the payment milestones as per the Domestic Building Contracts Act (DBCA) (1995) progress payments stages: base, frame, lock up, fix and final. The site supervisors' KPIs are measured heavily upon achieving both of these (time and payments). The supervisor is also the key interface between the builder and consumer. In saying this, they often represent the builder in the physical deliverable transaction of the house build. The consumers' predominant opinion of the builder will often be formed by their exposure to and relationship with the supervisor over the duration of their home build. Supervisors are typically not trained in consumer service, whereby their ability to communicate and interact with consumers could vary significantly. Research into consumer service and service quality specifically in the housing sector (Forsythe, 2008) has suggested that a

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consumers' experience and perception of the build process is developed over a length of time (not immediately as in a retail situation), whereby their exposure over this period of time will often define their ultimate level of satisfaction (positive or negative) and ultimate gauge of service quality.

The construction industry is made up of workers with a diverse spectrum of qualifications. Research has shown that compared to other industry sectors, almost half of the workers in the construction sector have completed a Certificate III or Certificate IV qualification, with only a small portion (8%) completing a higher education qualification, which in comparison, is low compared to other industry sectors (AI Group, 2015). Site supervisors in the volume building sector are quite diversified. In saying this, their skillsets, job knowledge, experience, and formal qualifications can vary significantly. Many supervisors have various trade qualifications at a Certificate III level; some have more extensive qualifications such as a Certificate IV or Diploma of Building and Construction. Research has shown that a lack of adequate education for site supervisors has directly contributed to the decline of the building industry's effectiveness (Farooqui, 2010). Over and above adequacy of education, research has also identified that key soft skills, job knowledge, and attributes consistently contribute positively to a projects' outcome. These include leadership abilities, technical knowledge, software skills, effective communication skills, strong negotiation skills, attention to detail, and problem solving abilities (Ying and Tan, 2015).

6. Planning and scheduling to ensure project completion

Software provides the site supervisors with a tool for call forwarding, scheduling, and procurement. The software packages also produce regular KPI reports and statistics for management to track based upon a diversity of efficiency and production parameters. What this allows the builders to do is keep an eye on the overall progress of works, cash flow forecast, and the general performance of site supervisors. The use of software means that procurement is linked to the scheduling whereby this process becomes automated as long as the site supervisors 'call up' in a proper and timely manner. What often happens is that the supervisors' book ahead of schedule in an attempt to remain organised given the quantity of homes in their portfolio. Unfortunately, doing this leaves little room for error should there be a delay along the project's critical path. Premature 'call ups' can adversely affect the overall project schedule, push out booked trades, and consequently affect the builder's cash flow forecasting. Typically trades will allocate their time across the number of projects 'on their books' for a diversity of builders, on a month to month basis. When a project is pushed out, they need to re-allocate the work, which generally means that the successor project will be reallocated to an earlier time slot. When the site supervisor goes to re-book the 'call up', the trade may be unavailable due to the relocation of work. What this

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means is that the project timelines can be negatively affected. This can push schedules out from a few days, to a few weeks depending upon the activity's relationship to the schedule's critical path. For many larger volume builders, cash flow forecasting is done at the start of each month (where managers forecast building permit numbers, site start numbers, and progress claims). A delay of time could potentially thrust a claim into the following month, having an unfavourable effect on the viability of the businesses' monthly cash flow forecasting. The practice of early 'call ups' is prevalent amongst many site supervisors increasing the risk of scheduling and claim forecasting errors having a significant impact on a builder's cash flow and viability.

7. After-sales service and warranty

The DBCA (1995) identifies the statutory implied warranties for all domestic building work in Victoria. The warranties centre upon the standard of workmanship and quality to be provided by the builder when entering into a 'Major Domestic Building Contract' (DBCA, 1995). The warranties are implied as they must be adhered to whether or not they are expressed in the contract, and cannot be contracted out of. A breach of any of the statutory warranties is deemed to be a 'defect' (DBCA, 1995). Most standard form major domestic building contracts have a maintenance period stipulated whereby the builder is responsible for remedying defects that manifest post settlement; this period precludes any general wear and tear of the home. With regards to builder maintenance obligations, recent case law, such as Metricon Homes v Softley (VSCA, 2016) and Watson v Richwall Pty. Ltd. (VCAT, 2014) has reiterated the importance of builders meeting their 'warranty obligations' under Section 8 of the DBCA (1995). What these cases demonstrate is that in Victoria, exists both robust statute and common law practices in place to protect consumers from domestic builders' poor workmanship which not only includes workmanship during construction, but in particular, how the workmanship holds up post settlement spanning the ten year statutory period. However, the level of protection has only been enforceable in the tribunal/court systems, where a consumer must take costly legal action in order to affect an outcome.

There is no insurance policy explicitly available to protect a builder from building defects claims over the statutory limitations period (10 years). What this means for a domestic builder in Victoria is that there needs to be a function within their business that is able to manage any 'structural defects' on builds for that period. For small to medium enterprises, this may be that the builder dedicates a portion of time per week to manage the completion of these items. The rectification of defects post settlement is done at the builder's cost. For volume builders, where the number of homes completed annually is significant, the defects per home post settlement represent a proportionate quantum of work to be managed for up to ten years; as a result, and in order to service this workload, many

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volume builders have set up a separate 'Maintenance Department' function. These departments are explicitly set up to service homes with issues post settlement; they do not generate revenue, on the contrary are an overhead. What this means is that larger builders have conceded that their function as a builder does not end at settlement (Levitt, 1983), and that good after sales/settlement service provides for better public relations, improves marketing, and builds greater consumer relationships (Anderson and Kerr, 2001) particularly in circumstances where the relationship during construction had been compromised.

CONCLUSIONS

This paper reports on the first stage of an on-going research project to improve the quality of build in the residential volume building sector. This reflective analysis by a residential building practitioner has identified seven critical factors that affect the quality of build: marketing, sales through to site completion; building inspections and audits; supply chain relationships; competency of site supervisors; project planning and control; and after sales service within which the residential sector operates. These factors have varying influences on each other, and are therefore interrelated and cannot be treated in isolation. It is apparent that there are a number of stages in the build process from sales through to maintenance that have insufficient levels of quality control and are directly impacting consumer satisfaction and potentially adversely affecting 'builder brand' and reputation. Given the prevalence of social media platforms (and word of mouth) for consumers to express their level of satisfaction, this places volume builders in a vulnerable position. In other sectors, such as manufacturing, total quality management (TQM) has proved to be a highly effective system for managing quality. The researchers plan to investigate the viability of adapting TQM practices to volume building processes in an attempt to create better consumer service quality outcomes.

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Electrical and Mechanical Safety in Repair, Maintenance, Alteration and Addition (RMAA) Works

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ABSTRACT

In Hong Kong, the repair, maintenance, alteration and addition (RMAA) sector becomes a more significant component of the construction industry with the implementation of the Mandatory Building Inspection Scheme (MBIS) by the Hong Kong SAR Government. Around 2,000 buildings would be targeted each year under the MBIS and it is expected that the volume of RMAA works will continue to increase. The public consultation paper issued by the then Housing, Planning and Lands Bureau (2006) indicates that the number of private buildings over 30 years' old in Hong Kong will rise to 22,000 by 2018. The condition of buildings becomes dilapidated as building age increases. Electrical and Mechanical (E&M) installations play an important role and involve a large number of practitioners. Among different types of accident, fall of persons from height and electrocution are the top two E&M works' killers. The safety of E&M work has not received sufficient attention. Only a very limited amount of safety research on E&M works especially in the RMAA sector has taken place. This study aims to reveal the causes of accidents on E&M works in the RMAA sector and provide recommendations to improve the safety and health of E&M practitioners. The significance of the study lies in providing a thorough E&M accident analysis in the RMAA sector, for the first time. A systematic approach with multidisciplinary inputs will lead to the identification of the causes of accidents and the formulation of holistic and practical measures for preventing accidents on E&M related RMAA works.

Keywords: Electrical and Mechanical; Safety; Construction Industry; Repair and Maintenance; Bayesian Network Approach

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INTRODUCTION

Electrical and mechanical equipment (E&M) installations are one of the indispensable tasks within the range of Repair, Maintenance, Alteration and Addition (RMAA) works. E&M works involve a number of building services trades, when dealing with such as air-conditioning, fire services, plumbing, electrical wiring and lift installations. According to the Census and Statistics Department (2016), the number of persons directly engaged in “building services installation and maintenance activities” in 2015 was 71,357 and representing over 35% of the number of persons directly engaged in “all construction activities” (n=199,861). In terms of the number of “building services installation and maintenance activities” establishments, it was 6,820 and accounts for around 30% of the number of establishments of “all construction activities” (n=23,342). In view of the number of workers and companies involved, the E&M sector is being regarded as a significant sector in the construction industry.

The urban decay issue has become a hot issue in Hong Kong during the past decade. The condition of a building deteriorates as it ages, due to natural “wear and tear” and the lack of proper building repair and maintenance (Law, 2008). With reference to the statistics from the then Housing, Planning and Lands Bureau (2006), there were approximately 39,000 private buildings in Hong Kong in 2005, around 13,000 of which were aged over 30 years. That number will rise to 22,000 by 2018. According to the latest report published by HK2030 (HK2030, 2016), the ageing problem of Hong Kong’s building stock is predicted to intensify in the coming decades because of the boom of building construction in 1970-1980s. Private building units aged 70 years or above will be increased to 326,000 by 2046, which is about 300 times of housing stock of about 1,100 units in 2015. These old private units are concentrated in the old urban areas, for example, Yau Tsim Mong District with over 60,000 by 2046 (Figure 1).

The Hong Kong government has taken various initiatives to improve building safety. For example, the Mandatory Building Inspection Scheme (MBIS) has been launched in 2012, which requires all buildings aged 30 years or above to be inspected as well as followed by necessary repair and maintenance work (Buildings Department, 2012). Each year, 2,000 target buildings would be selected for inspection under MBIS. To support the MBIS, the government provides a Building Safety Loan Scheme (Buildings Department, 2013) to help building owners to finance repair, maintenance and upgrading works on fire services installations, lift installations, electrical installations and gas risers. With this government strategy, it is expected that the number of on-going E&M related RMAA projects will substantially increase in the coming years.

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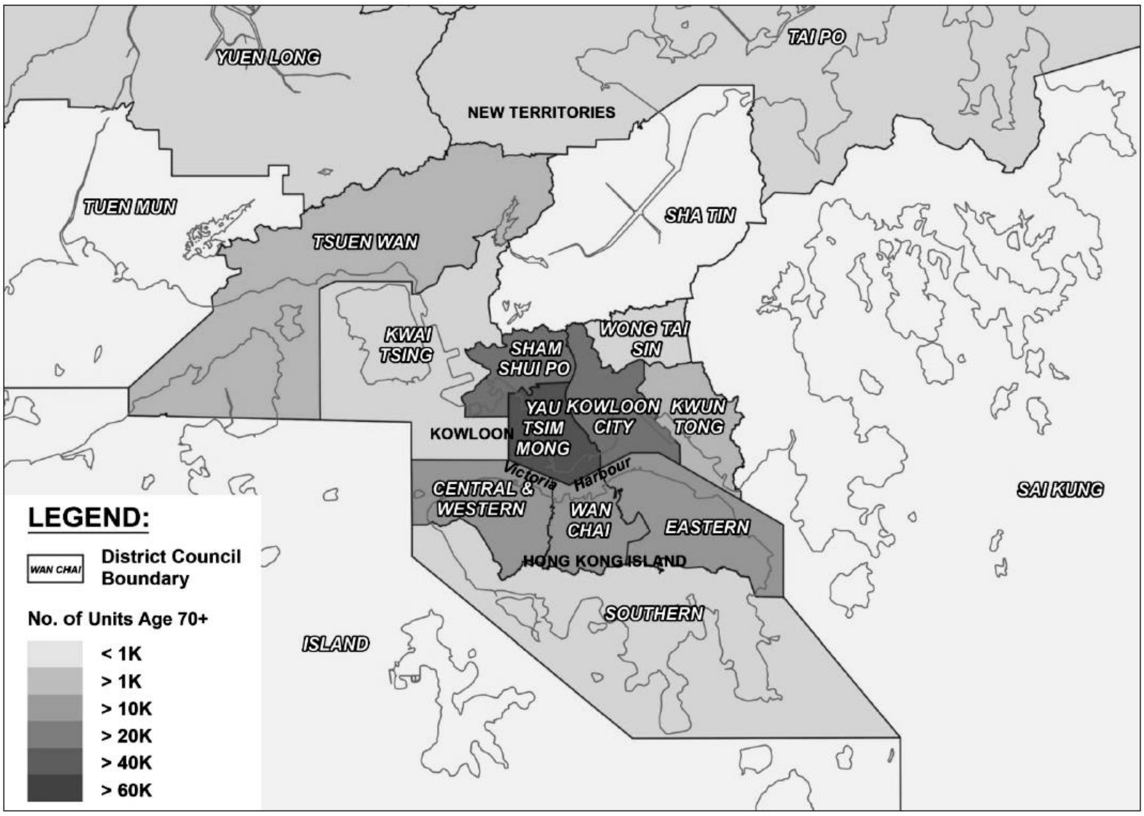

Figure 1. Private Housing Units Aged 70 or above by 2046 (by District Councils) (HK2030, 2016)

With this growing volume of E&M related RMAA works, it is predictable that the number of E&M accidents will also increase, which will not only cause project delays but also serious injuries and fatalities. A comprehensive research on E&M safety is vital to improve the safety performance of E&M works in RMAA. Despite the rising importance of this issue, there is limited study on E&M safety of RMAA works.

This research study aims to reveal the causes of accidents on E&M works in the RMAA sector with a Bayesian network approach and provide recommendations to improve the safety and health of E&M practitioners. The research will focus on the two major types of accidents, fall of person from height and electrocution. Among various safety analysis of accident causes, Bayesian network (BN) analysis is becoming a popular technique as it considers dependencies among variables to establish cause-effect relationships with a directed acyclic graph (DAG). This method is powerful to reveal complex cause-effect relationships and develop model for accidents prediction. In this study, accident cases collected from the Coroner's Court and the Electrical and Mechanical Services Department (EMSD) will be first analysed to preliminary identify the cause factors of E&M accidents. Focus group meetings with E&M works' practitioners and safety experts will identify values for the variables and indicate the direction of each pair of variables. Structured interviews will solicit views of different stakeholders to fine tune the BN model. In the last stage, a

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questionnaire survey will be conducted to collect more quantitative data for parameter estimation of the BN model.

RESEARCH AIM AND OBJECTIVES

Common E&M accidents include fall from height and electrocution, which are the top two killers on repair, maintenance, alteration and addition works in Hong Kong. The research study aims to reveal the causes of E&M works accidents with a Bayesian network approach and provide a series of recommendations to enhance the safety and health of E&M practitioners on RMAA works, particularly for those two types of accident.

Objectives of the study

1. To provide a critical review of the current E&M installation safety standards and safety performance on RMAA works.

2. To identify the causes of E&M accidents on RMAA works with a Bayesian network approach.

3. To identify effective measures to be implemented in order to reduce E&M accidents on RMAA works.

4. To give practical recommendations to various stakeholders on how to enhance E&M installation safety in the RMAA sector.

SIGNIFICANCE AND VALUE OF RESEARCH

Hong Kong, a highly developed and densely populated city with a very large number of ageing buildings. To maintain Hong Kong's ageing building stock appropriately and uphold public safety in a sustainable manner, it is vital to inspect and repair these buildings regularly. E&M installations represent a substantial proportion of all works in the RMAA sector. As repair and maintenance of air conditioning systems and water pipes always involve working at height, fall injuries frequently occur when using ladders. Most injured workers are unskilled labourers working on a temporary basis. For E&M works, the key hazards are being identified in activities that involve working at height, with electricity, in confined working spaces, lifting, machinery (for lift and escalator), welding, using handheld tools, etc. Some hazards in E&M works are quite particular, such as the E&M work processes in lifting of chillers and generators, electrical hazards at switch gear works, and confined space hazards around water tanks, etc.

Most air-conditioning and plumbing maintenance involves working at height outside the building. E&M fire services maintenance workers may have to work at a false ceiling level with a large ceiling void but no proper working platform. Lift maintenance works are complex and involve

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different processes such as lift pit working and lift machine room working that increase the likelihood of lift related accidents, because the spaces are particularly confined and complex. Wong, et al (2005) pointed out that the four factors: inappropriate equipment, lack of design for safety, lack of resources and insufficient housekeeping are the main factors contributing to fall injuries. Analysis of twenty-two case studies in Chan et al. (2007) revealed that falls from bamboo scaffolding were the most common accidents in the case of residential building repair and maintenance. In addition to fall accidents, electrocution is also a major type of E&M related accident.

A full investigation into the major causes of E&M accidents and corresponding improvement measures is urgently needed to formulate effective strategies to prevent related accidents in RMAA works. Currently, the research on E&M installation, especially for RMAA works, is tremendously limited. This research is essential to fill the research gap. Most of the existing studies used conventional descriptive statistics, such as factor analysis, analysis of variance, multiple regression, etc., to investigate the accident factors. An accident is often the combined outcome of a number of factors. These methods have inadequate ability in revealing complex cause-effect relationships and constructing model for predicting accidents (Martin et al., 2009 and Leu and Chang, 2013). Bayesian network (BN) is one of the recognized approaches to consider dependencies among variables to determine cause-effect relationships. In view of this, a BN approach will be adopted in this study to investigate E&M accidents in the RMAA sector.

It is anticipated that the study will provide insights into the root causes of both non-fatal and fatal E&M accidents and recommend a series of holistic and practical strategies to reduce them. It is expected to lead to an obvious reduction in fatalities and injuries in the RMAA sector. This contribution is not only beneficial to E&M workers themselves but also to the industry and the community.

BAYESIAN NETWORK APPROACH

Bayesian network (BN) approach has been adopted in accident analysis of different industry contexts. For example, Trucco et al. (2008) conducted a BN model to investigate organizational factors in risk analysis with a case study of maritime transport system. Zhao et al. (2012) analysed major factors related to hazardous material transportation accidents with BN approach. Regarding accident analysis in the construction industry, Zhou, et al. (2008) established a BN model to identify strategies for the improvement of human safety behavior by considering safety climate and personal experience. Martin et al. (2009) analysed fall from height accidents in the construction industry of Spain with BN. Nguyen, et al. (2016) demonstrated using BN to predict safety risk of working at heights in construction works. Leu and Chang (2013) and Zhou, et al. (2011)

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developed a BN-based safety risk assessment model for steel construction projects and deep foundation pit construction project respectively.

BN has demonstrated to be a powerful approach for accident analysis in complex socio-technical environments. It is a useful knowledge representation and reasoning tool which establishes complex dynamic model to visualize the probabilities interrelationships among a large number of independent and dependent variables (Heckerman, 1997; Tran , 2013 and Hanninen, 2014). It helps to identify the most significant causes of accidents. It has been extensively used to develop decision-support systems.

RESEARCH METHOD

This study will adopt a hybrid form of BN model construction, with expert knowledge to construct a prior BN structure and following by learning the parameters of the BN from questionnaire survey data. (Kjaerulff and Madsen, 2008; Zhao et al., 2012) The whole research process comprises: (1) updating the literature review; (2) case studies; (3) focus group meetings; (4) structured face-to-face interviews; (5) empirical questionnaire survey; (6) data analysis; and (7) validation of the results.

Literature review

The research will begin by conducting an extensive literature review of safety research on E&M works in the RMAA sector from textbooks, professional journals, conference proceedings, refereed publications, research monographs, workshop seminars, and internet materials across different countries including the United Kingdom, Australia and Hong Kong. An overview and analysis of applying Bayesian network approach in construction safety research will be conducted. Hong Kong accident statistics data will be obtained from relevant government departments (including the Labour Department, Electrical and Mechanical Services Department, Architectural Services Department, and Census and Statistics Department, etc.) and the patterns, nature and volume of E&M accidents related to repair and maintenance work examined and categorised. The review will facilitate the identification of factors leading to accidents of E&M works in RMAA projects as the variables for BN model construction. Besides, good E&M works practices in the RMAA sector will also be identified.

Case studies

Both fatal and non-fatal E&M accidents will be collected for analysis in this study. Information on fatal and non-fatal cases will be obtained from the Labour Department and the Electrical and Mechanical Services Department, further supplemented by the "WiseNews", an electronic database containing local newspaper archives (Hon and Chan, 2013).

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Accident cases collected from different sources will be triangulated to ensure accuracy and reliability of the raw data.

Cases files obtained from the Coroner's Court are another source of information for this research. The Coroner's Court has the power to inquire into the causes and circumstances of certain deaths. With the consent of the Coroner's Court, cases files of E&M fatalities in RMAA sector in the past 15 years will be examined. The files include information on police investigation files, death investigation reports, fatal accident reports by the Labour Department of the Hong Kong Government, autopsy reports and medical reports. The advantages of referring to the coroner's reports are that the data is highly reliable and strictly validated by police investigation of the circumstances and causes of accident (Gephart, 1993 and Goh et al., 2012). The purpose of case studies is to identify immediate factors and contributing factors of E&M accidents in RMAA projects. These factors will then become the variables of BN structure.

Focus Group Meetings

Focus group meetings will be arranged with safety experts and E&M works practitioners to gather expert knowledge on E&M safety of RMAA projects. It is an effective and convenient way to collect a large amount of information supplementing the traditional individual interview because the meeting itself generates synergism and stimulation among participants (Haslam, 2003 and Vaughn et al., 1996). The primary purpose of the focus group meetings is to gather expert knowledge for construction of the BN model structure. During the focus group meeting, the experts will be presented with the factors identified from literature review and case studies. They are required to indicate the interrelationships direction of the factors and base on their expert knowledge to preliminarily set values for the variables to construct a BN model. Based on the results of focus group meeting, a directed acyclic graph which presents the factors related to E&M works safety will be constructed.

Structured interviews

After preliminary developing the BN model structure from expert knowledge of the focus group meetings, about 20 structured interviews will be conducted with E&M practitioners of five key E&M installation trades, including air-conditioning, fire services, plumbing, lift installations and electrical works to fine tune and ensure that the BN model is realistic and applicable across the board to major trades of E&M works and at the same time reflects the unique characteristic in RMAA projects.

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Questionnaire Survey

A questionnaire survey will be conducted to collect quantitative data for parameter estimation of the BN model. Expectation-maximization (E-M) algorithm (Zhao et al., 2012) will be implemented using the software Netica (Norsys Software Corporation). Respondents will be required to rate and prioritize the causes of E&M accidents and measures for improving safety. A list of E&M accident causes and possible recommendations on E&M's RMAA works which has been consolidated previously will be reviewed and further modified. E&M frontline workers in the RMAA sector and RMAA contractors will be invited to participate in the survey.

PRELIMINARY RESEARCH FINDINGS

Based on the preliminary findings from literature review, air-conditioning installation is the most common trade leading to fatality among various E&M trades. According to the Labour Department (2016), there were at least seven E&M works related fatal cases occurred in 2016 (Table 1). Six out of seven fatal cases were occurred in RMAA works which far outweighed that of new construction works. It clearly reflected that the safety problem of E&M works in RMAA sector is significant. Among different types of accidents, fall of person from height and electrocution are regarded as the top two killers of E&M works.

Table 1. Fatal accident of E&M RMAA work in 2016, Labour Department (2016)

Date of accident	Trades	Type of works	Accident
January 2016	Air-conditioning	RMAA works	A worker fell from about 3m through the false ceiling onto the ground while replacing the air duct insulation material of an air-conditioning system.
February 2016	Lift	New works	A worker was struck to death by the descending counterweight of a lift while working at the lift pit.
April 2016	Air-conditioning	RMAA works	A worker fell from about 4m above ground while carrying out air-conditioning work inside a plant room of a building.
May 2016	Electrical wiring	RMAA works	A worker electrocuted while removing an electrical installation of a building.
June 2016	Plumbing & Drainage	RMAA works	A worker fell about 2.6m from a wooden A-ladder while installing water pipes near the ceiling of a shop unit.
August 2016	Electrical wiring	RMAA works	A worker received an electric shock while carrying out electric cable laying work inside the false ceiling of a building.

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November 2016	Air-conditioning	RMAA works	A worker fell from an aluminium folding ladder to the ground while inspecting an air-conditioning unit that was suspended from the ceiling.

CONCLUSIONS

Electrical and Mechanical (E&M) installation was identified as one of the most hazardous trades in the construction industry worldwide. Some trade unions and contractor associations of E&M works has expressed serious concerns for safety of their member practitioners in different occasions, especially in RMAA works. E&M installations involve a considerable proportion of workers in the construction industry. A safe E&M work is essential to the success of any construction projects. This research project provides an overview of E&M works related accidents in the RMAA sector, identify major factors leading to E&M works related accidents and formulate a series of safety measures through a series of research tools including focus group meetings, cases studies, structured interviews, and questionnaire survey. Bayesian network analysis will be adopted as a powerful approach for accident analysis to identify the most significant causes of accidents and supports decision making. It is expected that the research project will provide some insight into the practical and innovative ways to reduce the number of E&M related accidents in RMAA works. The research also facilitates productive discussions and engender innovative initiatives on this crucial subject of the industry and brings tremendous value in better safeguarding E&M workers' health and safety.

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Identifying the regional segmentation of retirement villages in four Australian states from the market perspective

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ABSTRACT

The retirement villages have become increasingly important for the community, practitioners and policy-makers across Australia over the decades. As one type of purpose-built housing, the retirement villages contain the heterogeneity throughout the designs, locations, implemented facilities, and services. However, relatively little attention has to-date been placed on identifying the regional heterogeneity of retirement villages across Australia. Nevertheless, little research has addressed whether the regional heterogeneity of retirement villages leads to segmentations from the market perspective. The purpose of this research is to investigate the regional heterogeneity and the associated market segmentations of the retirement villages across four Australian states. This research combined a content analysis and a market analysis of the elements of the retirement villages. The data relating to retirement villages in the four observing Australian states were collected from a specialised website for retirement villages. A hedonic pricing model was used where the price distributions relating to the elements were estimated. From the aggregate perspective, the design elements contribute to the price significantly; the elements of

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the facilities and services are less related to the price relatively; and the location and size of the villages have the weakest impacts on the price. However, the regional results confirmed the segmented market for the retirement villages across the four Australian states. The outcomes provide stakeholders with regional market information to assist in guiding the future direction of the retirement village industry and the local governments.

Keywords: Retirement village, price, regional segmentation, hedonic analysis, Australia

INTRODUCTION

The retirement village industry in Australia has developed rapidly over the past decades. In 2013 there were 2,160 retirement villages providing over 110,000 independent living units (ILUs) for approximately 177,000 seniors (RLCA 2014a). As an emerging industry, the retirement villages vary across the Australian regions from many perspectives. The definitions referring to retirement villages vary under different legislations in the states and territories. For example in New South Wales (NSW) the legislation refers to 'a complex containing residential premises which are predominantly occupied by retired persons who have entered into village contracts with an operator of the complex' (NSW 1999); in Victoria it refers 'to a community of independently living people who at a retirement age are required to pay an on-going contribution' (Victoria 1986). From a financial perspective there are four major types of contracts which relate to tenure for independent living units in a retirement village: freehold, leasehold, company title or licenses, and rental (Cradduck and Blake 2012). In addition, the retirement villages also vary from each other in the geographic locations and the design and structures. Therefore, it is arguable that the heterogeneity of the retirement villages should lead the segmentations on its sub-markets across regions, which is an important informative reference to industry practitioners, the elder population and policy makers but yet to be fully addressed.

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Segmentation has been widely recognised as one of the core issues in assessing interregional housing market (MacDonald and Taylor 1993). When housing submarkets are defined as geographic areas, the housing market segmentation demonstrates that the price of housing or the price of the housing characteristics appears distinctions with the reference to the locations (Goodman and Thibodeau 1998, Meen 1996, Tu 2000, Bourassa et al. 2003, Tu et al. 2007, Islam and Asami 2009, Gibler and Taltavull 2010, Gray 2012). Retirement villages are an important housing alternative for seniors which can offer enhanced life style and social interaction while also providing care and community support (Erickson et al. 2006, Miller and Buys 2007, Bohle et al. 2014). However, whilst accommodation in retirement villages is a realistic option for many seniors and the retirement industry continues to evolve rapidly on a global basis, overall it is still in a relatively early stage of development and requires further analysis and guidance (Zuo et al. 2014).

There are only a few studies being delivered to explore the demand market for retirement villages (Wiseman 1980, Gibler and Clements-III 2011, Gibler and Taltavull 2010, Gobillon and Wolff 2011). It remains uncertain how the market evaluate the elements of the retirement village and this has not been confirmed in the literature to-date. This research uses a hedonic pricing model to examine the function of the market based on the elements of the retirement villages based on data relating to 629 retirement village ILUs located in four capital cities in Australia. The sales information relating to the retirement village units are used in a market evaluation of elements relating to independent living units in retirement villages.

RETIREMENT VILLAGES IN THE FOUR AUSTRALIAN STATES

This research collected the detailed information relating to 629 retirement ILUs located in retirement villages in New South Wales (NSW), Victoria (Vic.), Queensland (Qld.), and South Australia (S.A.) in October 2015. The

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information is sourced from the retirement accommodation directory website http://www.villages.com.au which is the accepted industry portal as the primary search tool; this database also included information relating to listed 'for sale' prices and relevant retirement village characteristics. The statistics show that the elements of the retirement villages varied across the observing states. The median prices of the ILUs change from as the lowest as $286,380 in the Qld to as the highest as $350,000 in Vic. According to the RLCA the four most important pull factors attracting Australian seniors into retirement villages were independent living, quality and design of ILUs, security, on-site management and housing support (RLCA 2014a, RLCA 2014b). Accordingly, this research classifies the elements of the ILUs in the retirement villages into four categories: 1) structure of the ILUs, 2) village characteristics, 3) village facilities and 4) services and supports.

Structure of the ILUs

The overall structure of the ILUs appear the relatively smaller design as indicated by Figure 1.

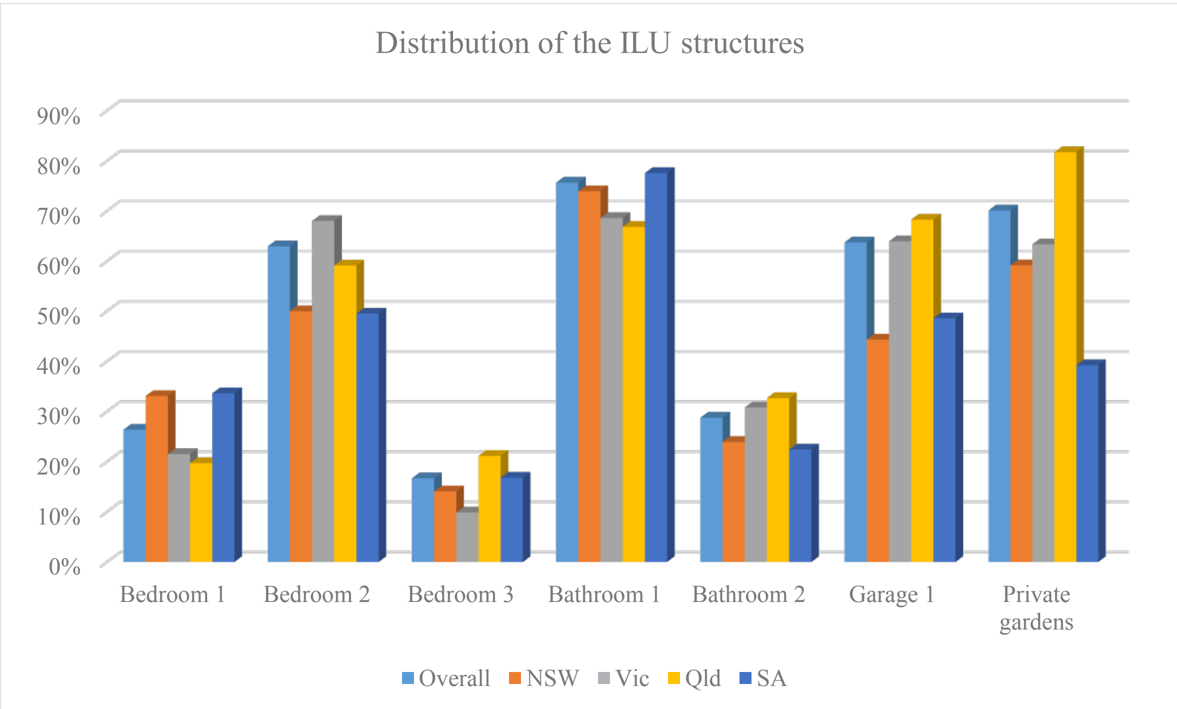

Figure 1: The structure of the retiremen-village ILUs in Australia

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The statistics show that over a half of the ILUs are two-bedroom units, and the one-bedroom and two-bedroom units take up to over 80% of the total observations. Over 75% of the units contain one bathroom, and the proportions the ILUs that contain one garage and a private garden are 63% and 70% respectively. The overall statistics suggests that the Australian retirement village industry aims to satisfy the down-sizing and easy-maintenance of the elder residents by providing the relatively smaller design of the ILUs. However, clearly reginal distinctions are disclosed across the four states. The retirement villages in the Qld tend provide larger living space, where the proportions of the ILUs that contain 3 bedrooms and 2 bathrooms are higher than the proportions in the other three states. Conversely, the smaller-size design appear relatively more popular in the NSW and SA. The proportion of the single-garage ILUs in the Qld is slightly higher than the overall level, while the proportions in NSW and SA are lower. In addition, there are over 80% of the ILUs contain the private garden in the Qld, while less the 40% of the retirement-village units have the private gardens in the SA.

Physical characteristics of the retirement villages

This research uses the size of the villages, which describes the number of ILUs within the villages, the distance from the retirement villages to the CBDs of the corresponding capital cities, and the locations of the retirement villages within the walking distance to the communities, to reflect the physical characteristics of the retirement villages. The statistics of the three elements are depicted by Figure 2.

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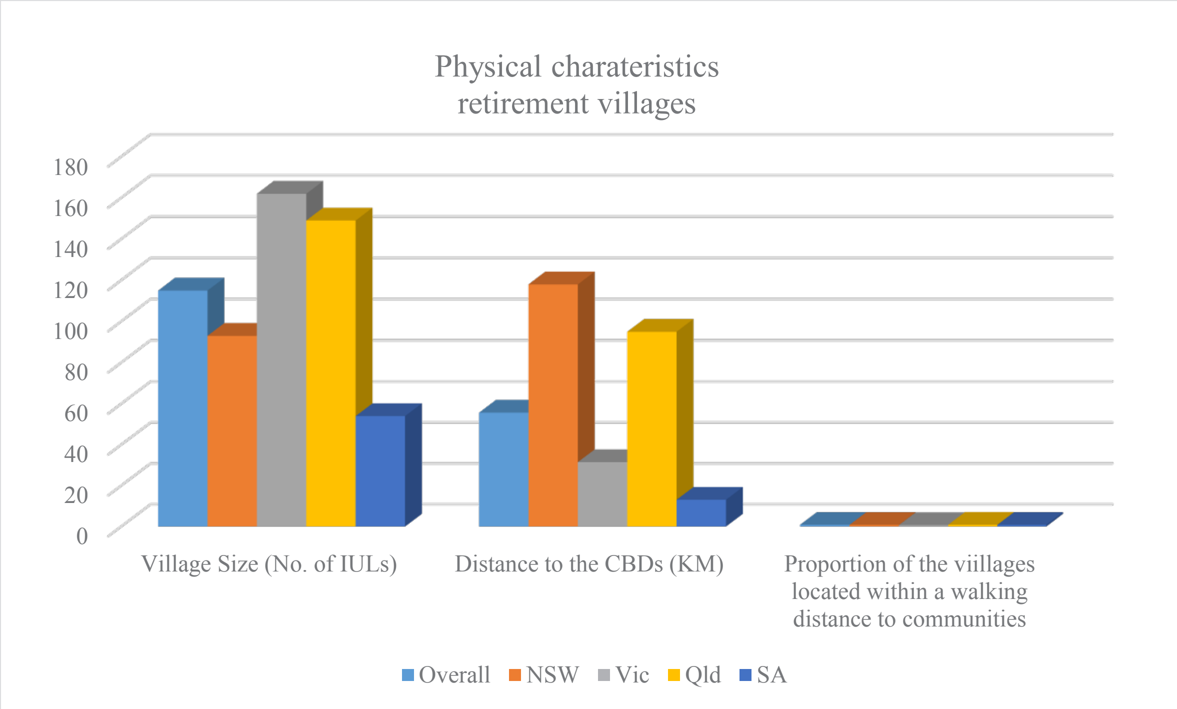

Figure 2: The Physical characteristics of the retirement villages

With reference to size, the median size of the retirement villages included 115 ILUs over the four states and ranged from 54 ILUs in the SA up to 162 ILUs in the Vic. The overall-average distance from the retirement villages to the corresponding the central business district (CBD) is 55.7 km. The retirement villages in the NSW (118km) and the Qld (95km) were located some distance from the CBD, however retirement villages in the SA (13.1km) and the Vic (31.5km) were located closer to the CBD. In addition, over 85% of the retirement villages were located within the walking distance to the communities. However, the proportion of the villages in the Vic is much lower than the overall level at 68%, indicating the retirement villages in the Vic has weaker community interconnections.

Retirement village facilities

The facility elements are composed of security, cinema, community centre, gym, high-speed broadband, library, pool, wellness centre, and other facilities contributing to luxury lifestyle. The distributions are reported by Figure 3.

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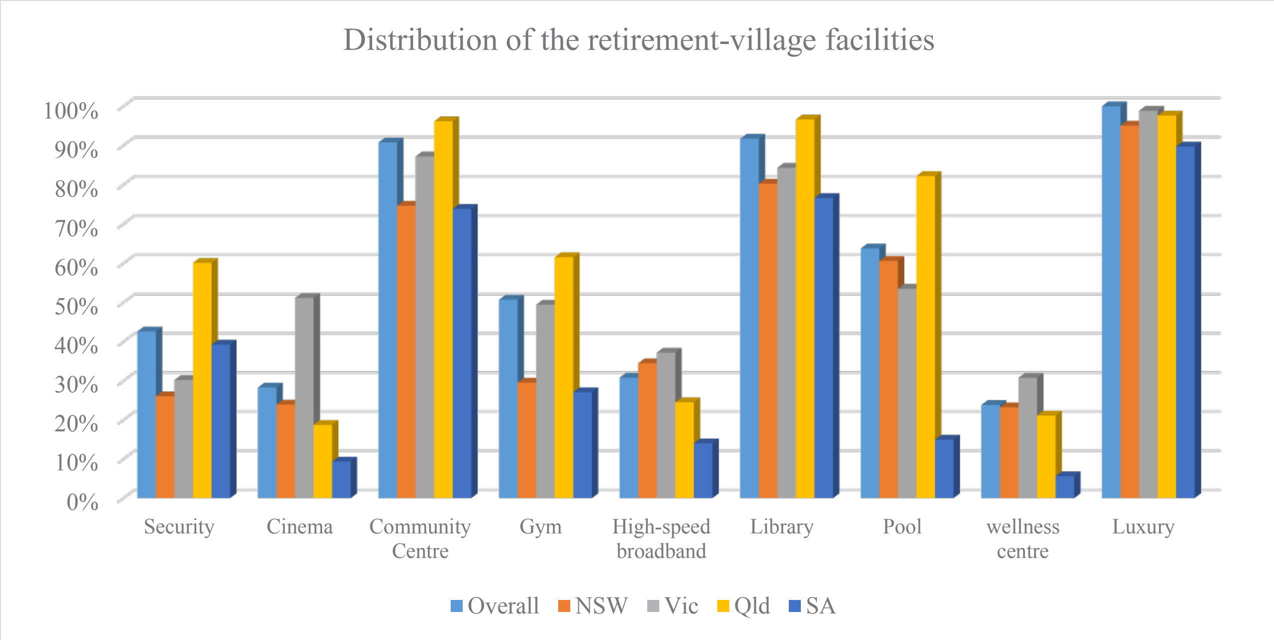

Figure 3: The distributions of the facilities in the Australian retirement village

The most common facilities were a community centre and a library which were observed in over 90% of retirement villages across the four states. Specifically, the villages in the Qld have the highest proportions at 96%, while the lowest proportions were found in the SA. In contrast, a cinema, wellness centres and high-speed broadband were the facilities least installed in a retirement village. For example a cinema was observed in 51% of retirement villages in the Vic although there was a cinema in less than 24% of retirement villages in the other states. Surprisingly less than 50% of all retirement villages incorporated security facilities such as CCTV, however this varied from approximately 60% of retirement villages in Qld to less than 40% in the remaining states. The proportions of the retirement villages that included a swimming pool and a gym vary the most obviously across the four states. There are over 60% and 80% retirement villages having gyms and pools in the Qld. However, in the SA there are only 27% retirement villages having gyms and less than 15% having swimming pools.

Retirement village services

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The services in retirement villages that were recorded by this research are 24-hour medical alert (78%), resident committee (72%), retirement village bus (63%), an onsite manager (58%), visiting medical services (42%), on-site staff (24%), and physiotherapy (11%). The details of the distributions are reported by Figure 4.

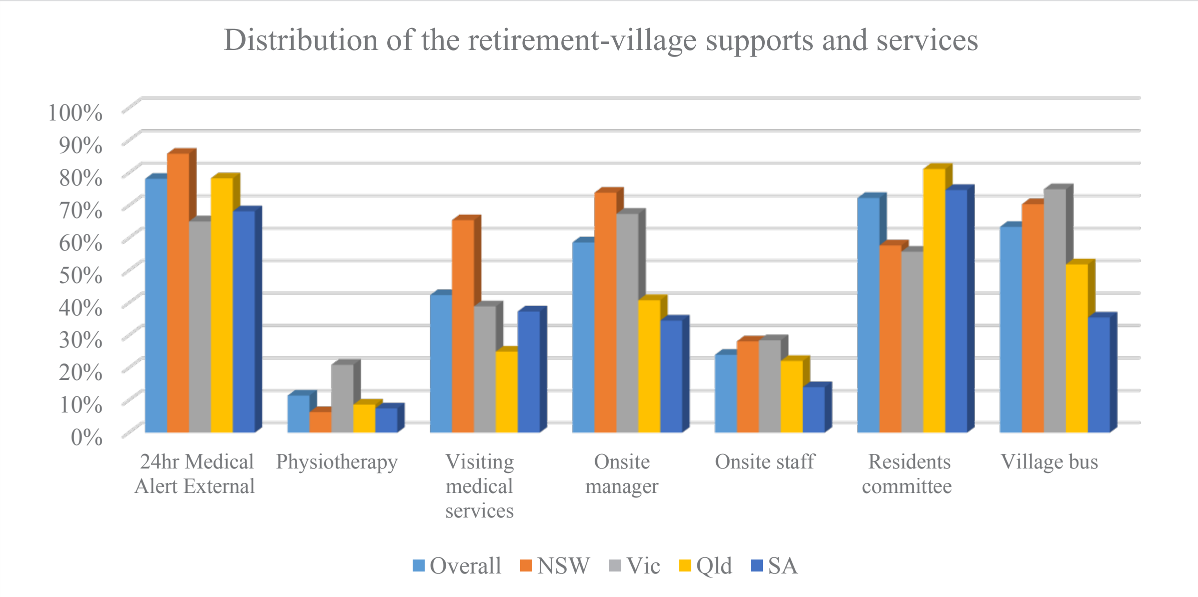

Figure 4: The distributions of the supports and services in the Australian retirement villages

The figure shows that the retirement villages in the Qld and SA have the relatively higher proportions of 24-hour medical alert and resident committee, while the villages in the NSW and Vic have higher proportions of the visiting medical services, onsite manager and staff, and the village buses. This suggest that the retirement villages in the Qld and SA tend to provide the residents with the lower level of the external support and services, comparing with the villages in the NSW and Vic. In other words, the residents in the Qld and SA retirement villages live more independently.

The statistics has disclosed the aggregate and distinct characteristics of the retirement villages across the four Australian states. The following part of this research is to identify whether the market evaluates the elements in a same way across the regions.

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MARKET SEGMENTATION OF RETIREMENT VILLAGES: HEDONIC PRICE MODEL

The housing price demonstrates the market equilibrium of residential accommodation is an indicator reflecting supply and demand of the utility-bearing elements (Wolpert 1965). A hedonic model based on the price of a good can be decomposed into a series of values of its elements and has been widely adopted to estimate the value of residential accommodation including houses (Rosen 1974, Hill and Melser 2008, Kuminoff and Jarrah 2010, Goodman and Thibodeau 2003, Helbich et al. 2013). This research adapted the hedonic approach to decompose the prices of ILUs in retirement villages based on the varying adjustments.

Since retirement villages are purpose-built then the level of support and services provided by retirement villages substantially influence a potential purchaser's preferences, which in turn affects the market price of each ILU. Each ILU in a retirement village also shares similar amenities and facilities; therefore the characteristics of a retirement village will have a large influence on the ILU price as well as the neighbourhood characteristics of the surrounding neighbourhood. Accordingly this research proposes a hedonic price model for the retirement village ILU which is expressed as follows:

$$P = \alpha_{\tau} + BX_{ILU} + \Gamma X_{Village} + \Omega X_{Facility} + \theta X_{Service} + \varepsilon \qquad (1)$$

where P denotes the sale price of a ILU; $X_{ILU}, X_{Village}\ and\ X_{service}$ are the vectors comprising the information of physical structure and location of the ILUs, the amenities of the villages, and services and support offered by the villages respectively; α_{τ} is the estimated constant denoting the external effect over a certain time period; $B = (\beta_1, \cdots \beta_m),\ \Gamma = (\gamma_1 \cdots, \gamma_n),\ \Omega = (\omega_1 \cdots, \omega_k),$ $and\ \theta = (\rho_1 \cdots, \rho_s)$ are the estimated correlation coefficients of the ILU elements, neighbourhood amenities, and spatial effects respectively; and ε

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records the estimated error between the actual and simulated prices. The hedonic model approach, as described by Eq.(1), assumes that people purchase a ILU in a retirement village that maximizes their utility (X_{ILU}), and marginal rates of substitution between local amenities ($X_{village}$) and other goods or ILUs ($X_{facility}$, $X_{service}$) over a certain period (α_{τ}), which can be measured by the correspondingly implicit prices of ILUs. In other words the hedonic model approach argues that ILU prices are related to the value of both market goods and non-market goods.

MARKET EVALUATIONS OF THE RETIREMENT VILLAGE ELEMENTS

This research estimated Eq.(1) separately for the four subsets, including NSW, Qld, Vic and SA, by using the ordinary least square method. The regression results are reported in Table 1, where the estimated coefficients indicate the market evaluations for the elements of the retirement villages. The significances are indicated by the p-values of the t-statistics tests against the corresponding estimated coefficients, reflecting the probabilities of the market evaluations. The coefficient is statistically significant at a 5% critic level if the p-value is less than 0.05.

Most of the design elements have positive and significant contributions to pricing the ILUs in the retirement villages across the four Australian states. However, the private gardens appear the opposite influences in the ILU prices. The bedroom was associated with the largest proportion of the ILU price across the four states, the market evaluations of which vary from \$62,667 per bedroom in the Qld to \$118,404 in the SA. The bathroom is evaluated at \$37,078 in the SA, \$41,332 in the Vic, \$56,453 in the Qld, and \$58,413 in the NSW. The garage component have the positive evaluations for the village ILUs, the significances appear vary across the states. The significances are 0.4182 and 0.2367 in the NSW and Vic, indicating that the effects of the garages on the ILU pricing are little. The private garden was negatively associated with the ILU prices overall.

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Especially, the private gardens in the Vic and SA are evaluated at -$120,611 and -$168,860 on the regional markets, with high probabilities.

The relationships between the ILU prices and the distances to the CBDs are significant in the NSW only, but insignificant in the other three states. In the NSW the price of the ILU will reduce by $279.84 as for every additional kilometre the retirement village was located away from the CBD of Sydney. However, the prices of the ILU in the other states are not sensitive to the distances between the retirement villages and the CBDs. A positive and significant relationship between the price and the village size was confirmed in the Vic only, where each unit price increased by $172 as the size of the retirement village increased by each additional unit. In addition, the community location was positively associated with the ILU price in the NSW and the Vic, where an additional $90,794 and $140,705 were associated with villages located within walking distance to the communities.

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Table 1: Estimations of the hedonic models for the four Australian states

	NSW	Qld	Vic	SA	NSW	Qld	Vic	SA
	Coefficients				Significance			
C	119,329.40	7,322.16	87,945.93	218,236.00*	0.1287	0.9123	0.3328	0.0069
BEDROOM	79,689.27*	62,667.86*	64,951.72*	118,404.60*	0.0000	0.0000	0.0022	0.0000
BATHROOM	58,413.85*	56,453.35*	41,332.35	37,078.18	0.0197	0.0001	0.0603	0.2224
GARAGE	20,508.63	57,175.90*	23,480.08	62,390.00*	0.4182	0.0001	0.2367	0.0075
PRIVATE_GARDENS	-39,750.51	-22,533.05	-120,611.80*	-168,860.80*	0.2760	0.4298	0.0236	0.0002
DISTANCE_TO_THE_CBDS__KM	-279.84*	0.59	42.03	-148.30	0.0000	0.9854	0.8253	0.2248
VILLAGE_SIZE	247.84	-12.01	500.90*	-558.34	0.1057	0.9446	0.0000	0.2305
WALKING_DISTANCE_TO_COMM	90,794.08*	-17,347.71	140,705.30*	56,453.76	0.0094	0.7522	0.0051	0.5814
CINEMA	-93,862.56*	38,798.24*	-31,701.21	279,778.90*	0.0485	0.0361	0.2286	0.0020
COMMUNITY_CENTRE	55,589.30	38,952.60	46,668.96	-10,075.88	0.1147	0.3494	0.3971	0.8424
GYM	154,975.40*	-73,749.59*	-13,932.75	-44,479.41	0.0001	0.0056	0.7182	0.3818
HIGH_SPEED_BROADBAND	3,864.37	73,665.81*	-26,592.62	11,896.51	0.8965	0.0002	0.2868	0.8271
LIBRARY	42,597.90	33,649.32	-17,282.78	115,121.90	0.3624	0.6543	0.7188	0.1281
LUXURY	-61,118.64	-50,668.65	-110,628.10	-216,273.80*	0.3011	0.5307	0.1980	0.0134
WELLNESS_CENTRE	-97,842.65	-25,014.26	-52,974.20*	14,440.27*	0.0120	0.2521	0.0484	0.8793
POOL	21,983.12	72,172.40*	58,967.13	46,195.94	0.3948	0.0052	0.1464	0.5944
SECURITY	-51,924.07	44,583.92*	-10,750.29	-87,738.73*	0.1214	0.0340	0.7372	0.0424
VILLAGE_BUS	-42,514.94	34,913.10	-44,131.60	-71,546.33	0.1273	0.0750	0.0612	0.0666
24HR_MEDICAL_ALERT_EXTE	-54,304.65	3,974.94	60,378.80	-138,891.90*	0.2496	0.8749	0.0559	0.0362
ONSITE_MANAGER	21,676.55	-69,181.19*	41,278.43	135,399.30*	0.5881	0.0000	0.1750	0.0001
ONSITE_STAFF	-14,176.99	-38,886.74	-3,082.22	50,986.03	0.6659	0.0560	0.8860	0.6058
PHYSIOTHERAPY	187,497.80*	35,271.15	25,683.14	95,848.58	0.0035	0.3377	0.5701	0.2805
RESIDENTS_COMMITTEE	-36,168.77	-9,372.45	6,650.50	109,893.10	0.2416	0.7478	0.8852	0.0553
VISITING_MEDICAL_SERVICE	21,710.24	61,318.72*	22,328.13	-80,909.04	0.4457	0.0060	0.4344	0.1096

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The estimations suggest that the market evaluations of the facilities in the retirement villages appear more segmented across the four observing states. Nevertheless, the majority of the facilities did not contribute to the market evaluations of the ILUs significantly. The estimation suggests that a cinema can raise up the price by $279,778 and $38,798 for a unit price in the SA and Qld respectively, but decrease a unit price by $93,862 in the NSW. The unit price increases by $154,975 when gym facility is introduced into the retirement villages in the NSW. However, including the gym facility in the villages in the Qld will reduce the unit price by $73,749. The security has a positive relationship with the market evaluation in the Qld, while a negative relationship in the SA. In addition, the high-speed broadband and the swimming pools can increase the unit price by $73,665 and $72,172 respectively. The unit price drops by -$97,842 in the retirement villages with the wellness centres in the NSW.

With reference to services and supports, the village bus and onsite manager are the most popular elements that can produce effects on the market evaluations of the retirement villages across the four states. Specifically, the village bus raises up the unit price by $34,913 in the Qld, but reduces the price by $44,131 in the Vic and $71,546 in the SA respectively. If the retirement village provided an onsite manager this represented $135,399 in the SA, but -$69,181 in the Qld. In addition the provision of physiotherapy services generate $187,497 to the unit prices in the NSW.

IDENTIFICATIONS OF THE MARKET SEGMENTATION

Overall the findings indicated the market closely associated the ILU price with basic retirement village elements, however facilities or services tended to have little association with ILU prices. Table 2 summarised the estimations results of the market evaluations to interpret the segmentations of the retirement village markets.

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Table2: Market segmentations of the retirement village in the four Australian states

Element categories	Elements	NSW	Qld	Vic	SA
ILU structures	BEDROOM	+	+	+	+
	BATHROOM	+	+	Nil	+
	GARAGE	Nil	+	Nil	+
	PRIVATE_GARDENS	Nil	Nil	Nil	-
Village characteristics	DISTANCE_TO_THE_CBDS__KM	-	Nil	Nil	Nil
	VILLAGE_SIZE	Nil	Nil	+	Nil
	WALKING_DISTANCE_TO_COMM	+	Nil	+	Nil
Village facilities	CINEMA	-	Nil	+	+
	COMMUNITY_CENTRE	Nil	Nil	Nil	Nil
	GYM	+	-	Nil	Nil
	HIGH_SPEED_BROADBAND	Nil	+	Nil	Nil
	LIBRARY	Nil	Nil	Nil	Nil
	LUXURY	Nil	Nil	Nil	-
	POOL	Nil	+	Nil	Nil
	WELLNESS_CENTRE	Nil	Nil	-	+
	Security	Nil	+	Nil	-
Village services and supports	VILLAGE_BUS	Nil	Nil	Nil	Nil
	24HR_MEDICAL_ALERT_EXTE	Nil	Nil	Nil	-
	ONSITE_MANAGER	Nil	-	Nil	+
	ONSITE_STAFF	Nil	Nil	Nil	Nil
	PHYSIOTHERAPY	+	Nil	Nil	Nil
	RESIDENTS_COMMITTEE	Nil	Nil	Nil	Nil
	VISITING_MEDICAL_SERVICE	Nil	+	Nil	Nil

It was evident that the market evaluations of the retirement village elements have represented obvious regional segmentations. The unit prices in the NSW and Vic are determined by less elements than the prices in the Qld and SA. The retirement villages in the Vic are priced the number of bedrooms, the size of village, and the community surrounding locations. Meanwhile, the market in the NSW tends to evaluate the number of bedroom and bathroom, the distance between the villages and the CBD, and the community surrounding locations as well. It is shown that the only a few facilities and services contribute to the market prices of the ILUs in the retirement villages in the NSW and Vic. The prices of the ILUs in the Qld and SA are determined by more elements. However, the physical characteristics of the retirement villages has little influence on the market evaluations. Instead, some facilities and services can significantly affect the market evaluations of the unit prices in the Qld and SA.

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CONCLUSION

Adding to the existing body of knowledge this research proposed an innovative approach to address the problem by examining the market supply levels and analysing elements of the existing retirement village ILUs and their relationship with the value of the retirement village. The results confirmed the most popular format of a retirement village ILU in Australia included two bedrooms, one bathroom, one garage and a private garden. Most retirement villages housed approximately 100 ILUs and although some villages were located a substantial distance from a CBD, they were located in an area surrounded by a local neighbourhood. The most common facilities in Australian retirement villages include community centres, libraries, pools, 24-hour medical alerts, village buses and onsite managers. The market value of the retirement village ILUs were mainly associated with basic elements, which has represented obvious regional segmentations. The unit prices in the NSW and Vic are determined by less elements than the prices in the Qld and SA.

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EXPLORING THE IMPLICATIONS OF URBAN VULNERABILITY TO INCIDENTS OF BUILDING COLLAPSE FOR CONSTRUCTION SAFETY RESEARCH

Number of words: 2,971 (minus abstract and keywords)

ABSTRACT

Engineers and architects have not yet developed a model for predicting when and where a building may collapse. However, the odds are high that any such incident(s) may occur in an urban setting, particularly in a developing country. This review bemoans on the public safety implications of the rising urban vulnerability to incidents of building collapse for our ever-urbanising world. It acknowledges the proactive turn that construction and building safety research has taken– i.e. the shift from, hitherto, ex-post facto analysis of trigger events to identifying and neutralising organisational preconditions that create vulnerability for failures to occur. It, nevertheless, contends that the questions that urban vulnerability to building collapse incidents raise, such as what web of forces are at play, why is it predominant in developing in contrast to advanced countries and their corollaries, are beyond the current scope of causes of vulnerability for construction failures research. It calls for more attention to the under-researched role that the broader socio-political-economic factors that influence construction processes and practices play in generating vulnerability for collapse incidents. Such endeavour, it is envisaged, could confer useful insights to affect broader social, regulatory and policy measures to address the phenomenon.

Keywords: building collapse/failures, construction accidents, urbanisation, safety culture, socio-political-economic factors

Introduction

Construction safety research has taken a pre-emptive turn. It has shifted from the, hitherto, ex-post facto analysis of trigger events. The shift in focus is grounded in the recognition that whereas there is always a technical/physical explanation for a failure, the reasons failure occurs are often procedural. Therefore, today, construction safety researchers and practitioners have rightly preoccupied themselves with specifying and analyzing how organisational, managerial, and workplace factors create conditions for failures to occur, provoke or trigger them. This review argues that while the paradigm shift has led to increasing implementation of quality systems, detection and prevention of errors in advance, and improved organizational learning, the rampant collapse of buildings in

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urban settings raises some compelling concerns that warrant a re-view of the conversation on the causes of vulnerability for building failures. The review could not have been timely and important enough as it provokes and stimulates a systematic re-view of the literature/approaches to the study of causes of vulnerability for construction risks at a time when they have become disturbingly recurrent. After this overview, the remainder of the article unfolds as follows: The next section explores the evolution of structural safety research regarding the causes of vulnerability for failures. The subsequent one captures the issue of urban vulnerability to incidents of building collapse. The final sections cover a discussion of the implications of urban vulnerability to incidents of building collapse for building safety and construction research and concluding remarks.

Structural safety research: An overview of the literature

Hitherto, structural safety research – the broader field of knowledge to which building and construction safety research belong – was forensic or remedial in approach: it involved retroactive analysis of how past accidents had occurred and application of the knowledge gained for preventing the recurrence of the specific error(s) that caused them. It was, thus, task or activity – based and backward-looking (Pidgeon, 2010). Much of the knowledge used to design, construct, manufacture, and operate engineered facilities and products have been obtained through learning from failures. The problem, however, was that causes of failures were known only after the fact. Second, it led to what is called in accident research circles as "tokenism" – as it only provided insights to address specific errors. Third, what mainly featured in the post-accident investigations were usually the immediate errors and violations, which, however, were just the triggering conditions for the manifestation of the failure (Perrow, 1984; Reason, 1990).

There is now the recognition that triggering factors (also called active failures) are rarely the principal instigators of failures. Instead, the real causes are usually the weaknesses created by fallible decisions made earlier in organizational and managerial spheres (Reason, 1990). Studies on failures increasingly report human and organizational factors as the major causes–only a few cases are attributed to the absence of contemporary technology or the state of the art (Blockley, 1980; Levy & Salvadori, 1992; Minato, 2003). Upon the growing recognition that, whereas there is always a technical/physical explanation for a failure, the reasons failure occur are often procedural (Yates & Lockley, 2002), researchers and practitioners have begun focusing on identifying and neutralizing latent failures –workplace, managerial, and organisational factors that combine with triggering events for them to manifest.

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It is widely acknowledged that the late Barry Turner's seminal work: *"Man-Made Disasters" (1978)* raised for the first time many of the key issues now taken for granted in the ongoing theoretical understanding of organizationally induced crises, and vulnerability for failures (Blockley, 1999; Minato, 2003; Pidgeon, 2010; Perrow, 1984; Reason, 1990). Based on a systematic qualitative analysis of a set of 84 British accident inquiry reports spanning a 10-year period, Turner found that failures were neither chance nor purely technical events. Rather, they arise from an interaction between the human and organizational arrangements of the socio-technical systems set up to manage complex and ill-structured risk problems. In this sense, the nature, origin, development and actualization of failures are conceived socio-technically.

Today, construction and building safety researchers are specifying organisational preconditions that enhance or create vulnerability for failures to occur in order to neutralize them (Andi & Minato, 2004; Atkinson, 2002; Atkinson & Westall, 2010; Jingmond & Ågren, 2015 Minato, 2003).

The collapse of buildings in urban settings: A global overview

Engineers and architects have not yet developed a model for predicting when and where a building may collapse, however, the odds are high that any such incident(s) may occur in an urban setting. A random recount of a few cases may be helpful. In the global north, some of the classic cases that commend to attention immediately may include the Versailles Wedding Hall collapse– the worst civil disaster in Israel's history that killed 23 people and injured another 380 at Talpiot–Jerusalem, the capital. In the US, one may point to the infamous collapse of the Hyatt Regency in Kansas City, Missouri, which killed 114 and injured 200 people at a tea dance. In addition, Wardhana & Hadipriono (2003) analyzed 225 cases that occurred spanning from 1989 – 2000. The data suggest that the collapses usually occurred at the heart of the big states –California, Texas, New York, Florida, Illinois, Pennsylvania, Ohio, Georgia, North Carolina and New Jersey. Further, the collapse of the 5-story Sampoong Department Store in the Seocho District of Seoul, South Korea resulted in the deaths of 502 people. The Seocho District, the incident location, is one of the 25 administrative units that make up the city of Seoul where over 10million people reside. Still, in the global north, a growing chorus of building experts in Australia have deplored what they project, as imminent "endemic failure of the building industry" if the growing trend of faulty building construction in Melbourne is not addressed (Dow, 2016). Melbourne is the capital and the most populous city in the Australian state of Victoria, and the second-most populous city in Australia.

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In the global south, where the incidents are even more rampant, some of the cases in Asia – the earth's most populous continent–include the collapse of the Royal Plaza Hotel in the city of Khorat in Thailand, which killed 137 people and injured another 227. Yet again, the location of the incident – Korat, is an urban setting. Korat is one of the four major cities of Isan, Thailand, known as the "big four of Isan". The collapse of Ranza Plaza in Bangladesh in April 2013 also killed and injured 1,129 and 2,515 people, respectively. Savar, the location of the incident, is one of the Upazilas (administrative centres) of the Dhaka District in the Division of Dhaka, very close to the Dhaka city. As Ranza Planza was tumbling in Bangladesh, their neighbours in India, Mumbra – home to about one million people, had experienced the worst building collapse incident in the area, killing seventy-four people, including eighteen children. Others include the Selangor incident in Malaysia, where an apartment collapsed and killed about forty-eight people. Selangor (home to over 6million people) is one of the states on the west coast of Peninsular Malaysia, encircling the capital, Kuala Lumpur. In November 2015, a factory building collapsed in Lahore, the capital of Pakistani province of Punjab and killed about forty-five people. Feifei (2014) has also compiled some cases in China and the trend shows that they usually occur in urban China.

In Africa –yet another hotspot for the incidents, there have been repeated incidents of building collapse in cities and urban settings. For instance, a six-storey building in Kampala, the capital of Uganda on April 11, 2016, reportedly collapsed and killed at least one person. Eighteen days after the Kampala incident, in Nairobi the capital of neighbouring Kenya, another six-storey building also collapsed and killed 49 people as several others sustained serious injuries. Alinaitwe and Ekolu (2014) examine other cases in East African countries' cities including Uganda, Kenya and Tanzania. The situation is even worse in urban Nigeria as severally reported by Oloyede et al, (2010); Ede, (2010); Windapo & Rotimi (2012) – to name but a few. Tchamba & Bikoko (2016) and Boateng (2016) explore similar incidents in the urban settings of Cameroon in Central Africa and Ghana in West Africa, respectively.

Implications of urban vulnerability to incidents of building collapse for construction safety research

The picture presented above is only indicative for there would not be enough space for even half of the incidents. However, the broader point is that construction failures are at the heartland of today's urban crisis, which, thus, poses an imminent existential risk to the present and not-too distant future of urban life, especially in developing countries. First, the odds of more building collapse destructions are growing by the day as the world is increasingly urbanising. The 21st century (projected to soon

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become the first urban century in human history – Gottdiener & Hutchinson, 2006) is marked by the growing concentration of large swathes of people in urban settings with about 54% of the world's population currently living in such areas. Two hundred years ago, Peking (today's Beijing) was the only city in the world with a population of a million people. Today, almost 500 cities are that big, and many are much bigger. The world's urban population has grown rapidly from 746million in 1950 to 3.9billion in 2014. It is projected that urbanization combined with the overall growth of the world's population could add another 2.5billion people to urban populations by 2050, with close to 90% of the increase to be concentrated in Asia and Africa – the hubs of developing countries where buildings collapse the most (Soane, 2016). Secondly, a significant share of global investments is trickling into building construction in urban centres (Knight Frank LLP, 2016) obviously to meet the residential needs of the many people thronging into such places and provide the needed infrastructure to support the ever-increasing commercial activities.

The situation could not be more worrying as a lot more people and massive investments stand at the risk of imminent peril. Measures to contain this looming danger may invariably need to be informed by an understanding of the broader connections in society that account for urban settings' high vulnerability to the incidents. However, this is where the problem gets even more aggravated. The challenge is that since the focus of the ongoing construction safety conversation is on organizational and managerial preconditions that induce, provoke or trigger vulnerability for failures, less emphasis is placed on broader societal factors. Thus, the role of the broader socio-political economic factors that influence construction practices and processes in generating vulnerability for failures either is discounted or insufficiently prioritized (Andi & Minato, 2004; Jingmond & Ågren, 2015; Minato, 2003).

The omission becomes even more fatal when against the growing recognition that a lot of the careless designs and inadequate construction practices that lead to collapse incidents may due to the growing socio-political economic pressures on the construction industry (Douglas & Ransom, 2013; Ortega, 2009; Tam et al, 2009). This could be so because, in the final analysis, as Watt (2007) puts it, buildings exist as physical response to people, place and the environment. It is not only, often not at all, engineering and architectural considerations that influence the construction process and practices. Rather, socio-economic and other considerations tend to be more important. A bad brick, lintel or joist is made, it is purchased subject or not to architects, planning and/or building safety specifications and procedures. The choice of material may reflect personal economy or available technology; it may also reflect image and a person's cultural sense of pride. But whatever the challenge to structural integrity or safety it is the social production of the forces underpinning the pursuit and the provision of building needs and services

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(construction processes and practices) that culminate to undermine it (Boateng, 2016).

The prevailing broader socio-political economic forces, thus, heavily influence clients and construction companies – their decisions, choices and behaviours, the prevailing construction practices. As such, the building structure cannot be conceived as just an assemblage of physical materials based on engineering and architectural considerations or a mere creation of structural integrity, but one of socio-economic and political-cultural means (Boateng, 2016). To, therefore, theorise causes of vulnerability for failures without recourse to the socio-political-economic factors and developments that influence or underpin the pursuit and the provision of building needs and services is to de-emphasize the social context of the phenomenon. In this way, limited insight is availed regarding how broader connections in society implicate on it and for instance its pervasiveness in urban settings.

There is the need for a much deeper level of analysis that problematizes the phenomenon of building collapse within the broader patterns of society – against the backdrop of the enduring socio-political-economic factors and developments that influence the demand and supply, design, construction, utilisation and adaptation of buildings. In this sense, measures to avert collapse incidents would be driven by a comprehensive understanding of the vulnerabilities they are supposed to reduce. A systematic examination of the social context of collapse incidents could also confer useful insights to affect broader social, regulatory and policy measures to address their high prevalence in urban settings.

Concluding remarks

The review has brought to the fore the issue of urban vulnerability to incidents of building collapse and has underscored its human security implications for our ever-urbanising world. It has acknowledged the proactive shift in focus of construction safety research to the identification and neutralization of organizational, managerial, and workplace preconditions that create vulnerability for failures to occur. It, nevertheless, has observed that even as this is a marked improvement over the previous activity or task – based forensic, remedial or ex post facto approach, it does not confer insight into the social context of construction risks such as building collapse incidents. It has argued that the neglect of the socio-political economic influences of construction processes and practices in the ongoing organizationally induced crises, and vulnerability for failures is a fatal omission as it decouples the incidents from the social contextual factors from whose interplay the failure incidents emerge. It is urged that construction and building safety researchers pay more attention to these under researched issues, as their

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examination could contribute to our understanding of the broader connections in society that account for the high incidence of the phenomenon in urban settings and in developing countries especially. Such an understanding would be useful as they could affect broader social, regulatory and policy measures to address the phenomenon.

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RURAL CONSTRUCTION MANAGEMENT FOR DEVELOPING ECONOMIES: IMPLICATIONS FOR PROFESSIONAL EDUCATION—THE CASE OF ASSAM

ABSTRACT

The authors are engaged in a three-year project, funded by the State of Assam, India, to develop new postgraduate qualification in construction management for Assam, and to research housing and infrastructure strategies aimed at improving rural life. The collaboration between the University of Melbourne and the State mirrors a common arrangement in international development assistance in which an institution from the Global North is invited to assist an institution from the Global South in improving the wealth and welfare of certain constituencies of the latter. However, the historical relationships between the North and South, and the way in which they play out in such arrangements has been critiqued from multiple perspectives. Those critiques suggest that the North-South divide is rooted in colonial history, is based on a privileging of the North over/against the South, and works to place the South at a perpetual disadvantage. It is important in undertaking this work for Assam that such critiques be acknowledged, and that educational products developed be as free as possible of such biases. This paper outlines the process by which the Project seeks to identify Assamese problems interests, source useful examples globally, and collect and synthesise them to create products that are tailored to Assam. The key findings: standard professional education is Eurocentric and does not relate to the construction needs of Assam's population, helps drive rural-urban and South-North brain drain, but that models are available to counter these tendencies, and can be used to create Assam-centric construction management education.

Keywords: Construction Management, Developing Economies, Professional Education, Rural Development.

INTRODUCTION

Professional education in the built environment professions—planning, architecture, engineering, construction—in developing countries is often modelled on the counterpart education in developed economies. There are several reasons for this, among them the colonial history of many developing countries, which saw these institutions set up by colonial powers to meet colonial needs, and the associated mythology of universal human progress or development, which suggests that all societies must follow the same pathway to becoming "developed."

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These professions have been configured to serve the needs of capital, and the middle class in the colonizing countries. This includes tacit assumptions of a specialised division of labour, complex supply chains, large budgets, a skilled trade workforce, relatively wealthy clients with large budgets, and well-developed existing infrastructure making access to sites easy and inexpensive.

In the State of Assam, the case study for this paper, these assumptions do not hold.

This paper shows that infrastructure needs and construction operating environment of emerging economies are substantially different from developed countries. The difference is most extreme in rural and remote parts of developing countries, in which the majority, and often poorest sector, of the population live. Conventional developed world construction management education does not adequately prepare local professionals for the challenges of this task. This analysis suggests fundamental differences in the knowledge need to adequately manage issues such as design for remote logistics and low skill levels, supervision of remote sites, procurement, maximising use of local resources materials and labour, simplified quality assurance, management non-standardised material supply chains, and designing infrastructure for easy local maintenance and repair. New knowledge has been developed to deal with these problems. The paper outlines a process for designing postgraduate construction management education that is tailored to Assam's development.

RESEARCH METHOD

The methodology for this paper has been developed in the context of the Assam Project, a three-year research project between the State of Assam, India, and the University of Melbourne, Australia. The general methodology is as follows:

1. *Problem identification:* Identify a problem in the State of Assam within the scope of the Project.
2. *Solutions search:* Carry out a global search, informed by a theory lens, for implemented examples that have the potential to address the problem identified. The search is focused primarily on implemented precedents supported by independent formal evaluations.
3. *Integrated design proposal:* Compile elements of these successful precedents into a new model for Assamese conditions, in close collaboration with Assamese counterparts and colleagues to ensure relevance and Assam-centricity.
4. *Testing and Prototyping:* Carry out testing of the proposed integrated design. This can range at the low end from user surveys or testing against expert panels, to fully realised field trials.

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5 *Policy formulation:* Prepare policy proposals for consideration by the relevant agencies of the State of Assam for consideration for roll-out.

This model of inquiry is based on principles of design theory (nowadays sometimes referred to as design thinking), professional design practice, and the program cycle model used in international development project and program design (Brown, 2008; ACFID, 2012).

This paper represents preliminary work on Steps 1 and 2 on the case covered by this paper: the requirement to research and develop a new Master of Construction Management [MCM] to be implemented first at Assam Engineering College, and then other institutions.

The central issue is that of fitness for the Assamese context. All education processes seek to prepare a student for a role in society. If the MCM is properly designed for Assam, then it will be focussed on the kinds of infrastructure work Assam needs for its development.

In this paper, this issue is address first via overarching questions of how to move from an unreflective Eurocentric professional education towards a more considered and targeted Assam-centric professional construction education with two objectives for MCM education:

- it serves all the population, including the rural (87% at as of the 2011 census), not just the urban (13%).
- it serves Assam's construction needs, not generic needs assumed from a different economic, geographic and developmental context.

Failure to achieve the first objective will bias the construction management profession against service of most the population. Failure to achieve the second will create a mismatch between labour force and development needs, as well as preparing—unwittingly—a labour force for complex urban economies in other parts of India, or overseas.

LITERATURE REVIEW

The literature provides several critical lenses through which to understand the Assamese context.

Global North, global South

The first of these looks at the bias of the Global North over/against the Global South, in which "geographic locations of nations are broadly identified with levels of industrialization, economic progress, science and technology, standards of living and political-economic power in the global arena" (Guttal, 2016). The risk here is if Australia is taken a model or objective for development, ignoring not just Assam's needs, but also its strengths which might take it in its own unique—and more competitive—direction. An example of a small region that have done this is the Greek domination of global shipping, based on its understanding of the Aegean, and the Netherlands, which now leads the world of flood engineering, based on its history as a country mostly below sea level.

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Centre-periphery and dependency

Another important lens is that that of centre-periphery models and dependency theories of development, which analyse locations in relation to hierarchy of central places and countries (Seers, 1981). In this sense, Assam is allocated as peripheral in many ways. First, it is a part of India, once a colony of India. Within India, it is considered largely a tribal state. It has also had a long history of conflict with the Indian centre, which set it up against the state of India. Third, it is geographically isolated by the geographical "gooseneck", and prevented from easy development by the its bisection and flooding by the Brahmaputra, which plays havoc with normal infrastructure planning, requiring elevated roads and very long bridges, both threatened with constant erosion. Though these can be considered as threats, they are also potential sources of competitive advantage, if engineering education focuses on dealing with the specifics of Assam, rather than a generic Eurocentric education in which it will be forever geographically disadvantaged, and historically consigned to playing catch-up.

Postcoloniality

The third lens is theories of postcoloniality, which sees these relationships as the after-effects of the colonial era: not just in terms of the divisions North and South, but in the status of cities which live off but hardly contribute to the countryside (Choudhury, 2016.)

Urban normativity

The fourth lens here is urban normativity, which privileges urban development over rural, and urban culture over rural culture, and the products of the urban economy over the rural. Though agglomeration economics tends to suggest that cities the will tend to have inbuilt economic advantage related to their internal connectivity, agglomeration can lead to an ecologic disadvantage, due to a dependence on transport for food and materials supply, and the concentrations of waste that urbanity creates. Related to this fourth lens is concept of "world cities in a world-system", which theorises that cities increasingly trade more with each other; that wealth is generated in world cities, and that cities are disconnected from their hinterlands (Knox and Taylor, 1995). This last suggests that cities no longer serve the countryside, but exist independent of it. This is not the case in material terms, only in an economy in which financial flows are increasingly disconnected from the material flows.

Freire

Within the realm of education, the thinker most clearly tied to questions of marginality is Paolo Freire. Freire sees colonial and capitalist power relationships process enacted out within the traditional education process through what he calls the "banking notion" of education. The banking notion of education imagines the teacher as full of knowledge and the student as empty, and the education process of a filling up of the student with the

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content already present in the teacher. Freire sees the learning process as primarily a liberating one, in which the teacher and student are both liberated from the confining structures of the past, and in which the teacher both teaches and learns, and the learner both learns and teaches (Freire, 1972).

Power structures

The above lenses help us seen an underlying structure: of two parties, one of which is full, the other empty; one of which has, the other has not. The relationship is one of transfer from the one that has, to the one that has not. This implies a power relationship of the full over the empty, and a value relationship of the have over the have not. The supposed situation of Assam is as peripheral, tribal, isolated, and rural, and therefore ever at the have not position. The supposed situation of the University of Melbourne, within the normal view is central, global, connected, and urban—full of knowledge in contrast to Assam's supposed emptiness.

It is this way of thinking that needs to be overcome if Assam is going to have an MCM which serves its interests, rather than a reflection of biased and neo-colonial worldview which serves only to diminish it. And the reason that these larger abstract ideas are important is that it is the underlying metaphors of the production of an MCM for Assam that will determine the outcome of the task of producing it (Schön, 1979; Lakoff and Johnson, 1980).

It is therefore critical that the relationship between the University of Melbourne team and its Assamese counterparts and colleagues not fall into these historical patterns. The objective must be to produce something new, something Assamese. To do so requires a model of research as co-learning, in which both Melbourne and Assam learn something new of transformational value.

RESULTS AND DISCUSSION

The centrality of construction management

Within this context above, construction management plays a special role, because construction management is concerned with the transformation of designs into physical reality. One might imagine that construction management is just one amongst many equal disciplines, it is construction manager that controls the efficiency and quality of the use of materials, and through which flows the design knowledge produced by the other disciplines.

Furthermore, good infrastructure is critical to the good functioning of the whole of the economy. No industry, even knowledge industries, can do well without transport, buildings, power, water, telecommunications, the management of overland flows, or well-housed, nourished, rested, educated, health and happy workforce, each dimension of requires its own

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infrastructure. Infrastructure is the operating environment of the economy. Again: without good construction management, infrastructure does not come into being. And if we think of construction management as part of an overall built environment lifecycle, it encompasses maintenance, upgrading, change and disposal of infrastructure.

By applying the theoretical lenses, we can see that to be an effective construction manager is in Assam is not the same as being an effective construction manager in Melbourne. It is not a scaled-down version of a construction management in Melbourne, but requires an equally important—perhaps more difficult—professional set of skills. If a CM in Melbourne needs concrete, he can pick up computer and order a load, and it will be there on time and to spec, without further thought, effort or knowledge on his part. In most of Assam, creating concrete requires finding and excavating suitable aggregate, cleaning and grading it, transporting and storing cement, and then ensuring that it is mixed, poured, vibrated, finished and cured by a workforce of largely unskilled people. This is a completely different set of skills. That same remote Assamese construction manager may know nothing about crane lifting safety protocols—but will likely never see a tower crane.

The following table shows the differences in construction between Assam and Melbourne, and is typical of the extreme differences in context between the periphery and the centre, the country and the city.

Table 1: Differences in construction contexts

Variable	*Australia*	*Remote Rural Assam*
Works	Complex	Simple
Geographical spread	Compact	Distributed
Supervision travel	Short	Time-consuming
Materials Logistics	Easy	Difficult
Contractor capitalisation and management	Adequate	Fragile
Labour	Skilled and specialised	Unskilled and unspecialised
Supply chain reliability	Well-developed	Often non-existent
Beneficiary populations	Wealthy, educated	Poor, semi-literate
Interest in local work opportunities	Low	High
Access to services	Easy	None
Weather	Benign	Sometimes severe
Disaster frequency	Rare	Annual flood

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The question: how to produce an MCM which is tailored to Assam, its peoples, and its interests. Following the methodology defined aboe, this comes in five parts, of which we deal with only the first two.

The first is the identification of the particular challenges that Assam faces, and the particular constructional needs of its people. These will determine what kind of construction manager is needed—to produce what works, and under what conditions. As noted before in the examples of Greece and The Netherlands: challenges tend to produce strengths. The table above makes a start towards identifying the challenges, but there is still work to be done with our Assamese counterparts and colleagues, because the answers are not only to defined by them as a matter of practicality, but as a matter of right: to define needs and strengths that defines the future of CM education.

The second part, coming from our methodology above, is to sources and analyse potentially useful precedents from other parts of the world. A precedent has two uses:

- First as a case study, from which can be drawn lessons for an Assam-centric solution
- Second, by being contrary to the established norms, providing evidence that Assam is not required to adopt or follow Eurocentric norms, unless Assamese context and interests make it logical to do so. The norms are so commonplace that they become tacit assumptions. Counter-examples deconstruct those assumptions.

Preliminary research so far has revealed the following possibly useful examples. They fall into three categories: pedagogical, conceptual, and institutional:

Towards a new set of exemplars

The first two examples are pedagogical, looking at new ways of considering education aimed at rural life.

1 *The Rural Studio*

The Rural Studio is an acclaimed architectural educational program at the School of Architecture, Planning and Landscape Architecture at Auburn University in Alabama, one of the more rural states in the United States. It was founded in 1993 by Samuel Mockbee, and has been run continuously ever since. (Ruralstudio.org, 2017)

"The Rural Studio is a design-build architecture studio run by Auburn University. It aims to teach students about the social responsibilities of the profession of architecture while also providing safe, well-constructed and inspirational homes and buildings for poor communities in rural west Alabama, part of the so-called "Black Belt" (En.wikipedia.org, 2017).

Not only does the Studio orient students towards problems in their own State, but through its methodology it provides a tacit curriculum which

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teaches students to combine design and construction, and to look for projects among the rural poor.

2 *Rural Engineering*

Urban engineering assumes complex projects with high levels of specialisation. Rural engineering is a topic of study at many tertiary institutions which breaks this pattern, by combining all forms of engineering that are useful in one context: rural. Graduates of these courses become rural engineers, with their own associations, professional development, and awards for excellence. They are not defined by mechanical, electrical, structural or civil, but by where they work.

The structure of rural engineering education holds promise for lessons in how to develop construction managers who are useful in rural Assam.

The next two examples are conceptual: they provide total frameworks for conceiving in the first place the act of designing and constructing built works, and in the second a "clean slate" to the creation of a learning environment.

3 *Critical regionalism*

Critical regionalism is an approach to architecture—and through architecture to other forms of infrastructure—which takes it as given that architecture and construction are not universal, as is often presupposed in the culture of modernity. Each has to be fitted to local place, culture and resources (Frampton, 1983).

Critical regionalism starts with looking at the built environment and production practices of a region to date, and applies a critical approach to improve those practices piecemeal, while retaining what works well. Most countries in the world today, in all regions, have some form of critical regionalism (whether it's called that or not) at work in the production of the built environment.

Critical regionalism—and its practitioners in developing countries—provide an encyclopaedic source for adapting design and construction practices to a local region, building on its strengths and developing its local economy.

4 *New Designs for Learning*

The New Designs for Learning is a research program in the United States led by Dr George Copa, and funded by the Federal Government. The New Designs methodology has been applied to both secondary and tertiary institutions, and began with the observation that the American high school has little changed since its invention over a hundred years ago, aimed at turning migrant children into effective factory workers.

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The workplace today is very different for the Fordist plants of the time, and yet the high school remains similar in its structure, incorporating many of Fordist principles in the way it teachers: it assigns students individual workstations, gives them standardised assignments, and grades their output. Yet in a modern knowledge workplace, people work in multidisciplinary teams, on problems with no known answers, and their success depends upon the ability to convince others of their solutions.

The New Designs methodology starts with the key educational stakeholders—parents, teachers, industry. From them, it identifies educational outcomes tuned to the current day, then the educational processes needed to delivery those outcomes, and then the educational

The final two exemplars look at what kind of institutional support an MCM might need.

5 *The International Centre of Theoretical Physics in Trieste*

The centre was founded in 1964 by Pakistani Nobel Laureate Abdus Salam. It grew out of his experience as a graduate in physics returning to his home country, and finding that his sponsor—the government at the time—had no idea of what physics was, and were unable to assign him a place in which he could practice his trade. He was forced therefore to move to the UK, which he considered unfortunate. He wanted to stay and contribute to his home country.

Salaam set up the ICTP so that scholars from developing countries could take breaks from their home environments, meet others like themselves, as well as physicists from the global North. Significantly, the Center is located in a rural setting in Italy, outside of Trieste. Today, the ICTP has a branch in Brazil, and publishes the African Journal of Physics.

What's significant about the ICTP is it recognises the challenges faced by scholars and professionals in the global South, and to providing a facility oriented towards those challenges. It also is significant in being an example of what is called 'South-South dialogue': countries of the global South seeking to learn from each other, instead of from the global North.

These last two attributes may be useful in the design of the institutional framework for the MCM: that it seek lessons from the global South, and that as an education program it provides ongoing opportunities for graduates to stay in Assam, and work in the most difficult parts of the state.

6 *Mawlynnong* (Indiatoday.intoday.in, 2017)

In thinking about institutions, it's natural to think about formal urban institutions. But the most important institution in India today is the village, which still provides home and livelihoods for some 80% of the

India's population. What's extraordinary about the village of Mawlynnong is two-fold:

- It has transformed itself into the self-called "cleanest village in India". This involved not just new social processes and behaviour changes, but infrastructure which was itself clean and cleanable: well-built and finished.
- In so doing, it has put itself on the global map, and thus on the tourist map, thus generating additional income for itself.

Mawlynnong demonstrates two principals discussed in this paper. First, they addressed local needs through infrastructure. Second, in so doing they became more than just another village in India: they became themselves a globally renowned example of village development. Finally, it has done so in a way that is economically rewarding.

Finally, Mawlynnong provides this key listen to educated, urban professionals: never underestimate what a village can do.

These examples, and more, will require in depth study to yield reliable lessons for potential application to Assam. Even at this stage, however, they demonstrate the kinds of possibilities that are covered over and unseen with the lens of the conventional North-South paradigm.

CONCLUSIONS

This paper has discussed the ways in which Assam—because of its rurality, its river, it's geographical isolation, its plurality of its colonial history, and it's resistance to absorption into the Indian polity—is in many ways a paradigmatic case of marginality within the global and national power structures at work in the world today. These power structures are not simply external, but colonise our ways of thinking about the world, and endanger a project such as this one it we allow them to lead us to unreflectively recreate them in the way in which we design future education programs, such as the MCM for Assam.

Approaching a collaboration between an institution in Melbourne and its counterparts and colleagues in Assai requires an awareness of these background power structures in the way in which they inform thought, and hence the production of a Master of Construction Management.

The hold that historical forms of thinking about the relationship between the global North and South can be loosened by adopting a Freirean stance not just to the content of the MCM, but to the relationship of the various producers: as co-learners.

It can also be loosened by examining successful exemplars from around the world which show that the relationship between North and South, centre and periphery, and city and country are not cast in stone nor

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determined by nature. These relationships were created by human beings, and as such they can be re-created by human beings in a different mould.

Future work will involve completing the cycle of the methodology through close engagement between researchers at Melbourne, and civil servants, researchers, practitioners and communities in Assam. It will also involve finding other exemplars, analysing them, and distilling lessons thus learned into a uniquely Assamese Master of Construction Management.

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FACTORS AFFECTING CONSTRUCTION STUDENTS' SATISFACTION WITH GRADES IN DESIGN COURSES

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Abstract

The construction and built environment sector is dynamic. It is made up of professionals who are knowledgeable about design, planning, construction and cost estimation. Design is one of several courses undertaken by construction students. Assessing design drawings is demanding for tutors as the assessment criteria need careful consideration. Assessment results may encourage or discourage students. Their morale may be affected if they feel their efforts have not been rewarded. Achieving a balance between the tutors' decisions and students' satisfaction is therefore important. This research sought to identify factors affecting students' satisfaction with grades in design courses. The study was undertaken among year 3 and 4 architecture students in a Nigerian university. One hundred and twenty students were invited to reply to an online questionnaire. Their responses revealed that most of them were not satisfied with their tutors. They felt that marking was inconsistent. This study identified a range of ways students felt assessment could be improved. Chief amongst these was a suggestion that the same tutors assessed the work of all students (rather than for several tutors to be involved). Based on these issues, the paper suggests ways to balance tutors' assessments and students' satisfaction.

Keywords: design courses, grades, students' satisfaction, tutors

1.0 INTRODUCTION

The term "satisfaction" is commonly used when describing the concerns of customers or clients of a product or service particularly in business and marketing industries. Many definitions of satisfaction exist in literature, most of which are from the business and marketing point of view. For example, Oliver (1997) described satisfaction as consumers' pleasurable fulfilment that their consumption meets certain goals and desires. Similarly, Fornell

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(1992) viewed it as the evaluation of a perceived product before and after purchase. High levels of satisfaction of a product or service may be achieved when end users express pleasurable feelings and vice versa. Assessing users' satisfaction of a product or service is a common phenomenon whose results are used to either enhance or change the product. This ideology has been applied in several industries offering products and services including educational institutions.

Universities are responsible for providing education to students. They are service providers, and their students are consumers (Thomas & Galambos, 2004). To ensure constant growth in a competitive market, it is important that consumers are satisfied with services. Many universities have designed methods to evaluate their performance in terms of service delivery. Students are commonly used data for such evaluation (Pozo-Munoz et al., 2000). Surveys such as interviews and questionnaires e.g. student feedback questionnaire (Coffey & Gibbs, 2001) are widely used in evaluating students' satisfaction. Others include a Student Rating System (SRS) developed in Kansas State University (IDEA, 2007); Student Instructional Report (SIR) developed by Education Testing Service (ETS, 2006); Student Evaluation of Educational Quality (SEEQ) developed by Marsh (1987, 1991); College Student Satisfaction Questionnaire (CSSQ); Student Course Satisfaction Scale (SCSS) developed by Seoul National University (Byun & Kim, 2003); and Course Experience Questionnaire (CEQ) developed by Graduate Careers Council of Australia.

Table 1: Categories of students' satisfaction

	SEEQ	CSSQ
1	Learning and value	Policies and procedures
2	Tutor enthusiasm	Working conditions
3	Organisation clarity	Compensation (cost and benefit)
4	Group interaction	Quality of education
5	Individual rapport	Social life
6	Breadth of coverage	Recognition
7	Examinations/grading	
8	Assignments/readings	
9	Workload	

Similarly, models have been developed and tested to identify and explain factors responsible for students' satisfaction. For example, De Vore and Handal (1981) developed a five-factor model, which comprises working conditions, compensation for cost and benefit, quality of education, social life and recognition. Clemes et al. (2008) also developed a three-factor theory with various sub-factors. It includes interaction quality, outcome quality and physical environment. Several other factors identified in literature includes tutors' direction and support, students' commitment to learning, course factors (Lo, 2010), facilities and resources available (Garcia-Aracil, 2008), quality of education, and social factors (Elliot & Healy, 2001; Wiers-Jenssen, Stensaker & Grøgaard, 2002). The CSSQ and SEEQ have been used to measure students' satisfaction in six and nine categories respectively (see Table 1). Other categories and sub categories included

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students' characteristics: entry qualifications (Ofori, 2000); gender (Tatro, 1995); disability status (Scullion, 2000); ethnicity (Chevannes, 2001) and age (El Ansari & Oskorochi, 2006). Also included are the course characteristics study mode (Lee et al., 1999); course level (Kerridge & Matthews, 1998); course module and the qualification aim (Eaton et al., 2000; El Ansari, 2002).

Assessing students' satisfaction helps to identify areas of weakness and strength (El Ansari, 2011). It provides room for improvements and helps administrators focus more on teaching quality (Solinas, Masia, Maida, &Muresu, 2012; El Ansari, 2002). More so, it will contribute to high educational standards through a direct focus on issues of quality development (Wiers-Jenssen, Stensaker, & Grogaard, 2002). Effective use of the feedback provided by students could improve learning and teaching quality (El Ansari, 2002), allows for course comparisons and improvements (Solinas, Masia, Maida, & Muresu, 2012) and also highlights students' perceptions of learning and the learning environment created by tutors. Worthy of note by some authors (Umbach and Wawrzynski, 2005; Lo and Olin, 2009a, 2009b; Lo and Prohaska, 2009) is the fact that tutors' roles may be significant in students' satisfaction. They argued that their roles could not be over-emphasised being the course designers whose creativity facilitates students' learning. Therefore, the quality of teaching staff or tutors is a reliable tool in assessing students' satisfaction.

Aside from the quality of teaching, the grades awarded to students by tutors also contributes to students' satisfaction. According to Marsh and Dunkin (1992), attention has now shifted to students' satisfaction with grades obtained at the end of a course. For instance, Pike (1991) examined the relationship between students' grades and satisfaction; he concluded that satisfaction exerted a greater influence on grades than grades do on satisfaction. However, other researchers (Lo and Olin, 2009a, 2009b; Lo and Prohaska, 2009; Umbach and Wawrzynski, 2005) disagreed with Pike's findings. This implies that there are conflicting views about satisfaction and grades. Most studies have focused on the relationship between satisfaction and coursework grades. However, few have examined satisfaction with drawing or design courses and the systems adopted to grade them.

Design is one of several courses undertaken by students in the Architecture, Engineering and Construction (AEC) sector. This sector is made up of professionals who are knowledgeable about design, planning, construction and cost estimation. Many tutors at institutions offering architecture, engineering and construction management have been required or expected to assess students' design drawings. It is demanding for tutors, as the assessment criteria need careful consideration. Assessment results may encourage or discourage students. Some researchers have examined how tutors' assessments influence students' satisfaction. Students may react positively or negatively to the grades awarded them, which could affect learning outcomes. Their morale may be affected if they feel their efforts have not been rewarded. Therefore, achieving a balance between the tutors'

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decisions (grades) and students' satisfaction is important. Numerous studies on students' satisfaction have been reported but not fully explained (Benjamin and Hollings, 1995; 1997). Most studies focused on satisfaction with grades, style of teaching as well as the infrastructure or facilities provided. However, students' satisfaction with their tutors and the grading systems they adopted have received little attention. This suggests that there is a lot of ground to cover in the area of students' satisfaction. This study therefore sought to discover construction students' level of satisfaction with their tutors based on their scores or grades. The null hypothesis (H_0) is that there is no significant difference in construction students' level of satisfaction with their tutors based on their grades. Factors affecting students' satisfaction with grades in design courses were also identified in the study.

2.0 METHODOLOGY

This study employed a survey administered within the first semester of the 2016/2017 academic session at the department of Architecture, Federal University of Technology Akure (FUTA), Ondo State, Nigeria. Interestingly, the duration for architecture programmes at the university is five years for a freshman and four years for direct entry. Students enrolled in this programme usually start design courses in year 2. The study was undertaken among year 3 and 4 students. They were invited to reply to an online questionnaire based on their experiences with their last design course (i.e. Architectural Design – ARC 201 and ARC 301). Students were asked to answer five questions about their satisfaction with grades and the factors that affected them, as well as questions about demographics. The factors affecting students' satisfaction were adapted from literature and grouped empirically.

Students were asked to respond to the questions on a 5-point Likert scale with the following answers: 1 strongly disagree, 2 disagree, 3 neutral, 4 agree, and 5 strongly agree. The questionnaire included one "open-ended" question aimed at eliciting students' opinion on how design course assessment could be improved. Participants were recruited from the attendance register signed with the design course coordinators. Only those who included their email address in the register were contacted. Overall, 120 students were emailed. The link to the online survey was sent to them with the study's objectives. Participants were made to understand that their consent to participate was implied by submitting the survey and that the survey was voluntary. To do analysis, weighted average of responses (descriptive statistics) and Pearson correlation was performed using SPSS.

3.0 FINDINGS AND DISCUSSION

One hundred and two students responded to the survey, which represents 85% response rate. Two factors could be responsible for the high response rate. One, internet access, which is readily available on most smart phones used by students and two, the survey was student centered. The survey results are presented below:

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Profile of respondents: Table 2 shows students' demographic profiles. 76.5% are male while 23.5% are female. This is a fair representation of the actual population of students studying architecture in most universities of technology in Nigeria. The majority of the respondents, 73.5% were aged between 20 and 24. The number of year 4 (400 level) students that completed the survey were 54 (52.9%) while 48 (47.1%) were year 3 (300 level). This implies that majority of the respondents are experienced having been graded at least twice (i.e. year 2 and year 3) in their design courses. Furthermore, 70.6% have secondary schooleducational background; none of the students had technical college educational background while 29.4% had polytechnic educational background.

Table 2: Respondents' profile

Respondent profiles	Frequency (%)
Gender	
Male	78 (76.5)
Female	24 (23.5)
Age group	
15 – 19	6 (5.9)
20 – 24	75 (73.5)
25 or older	21 (20.6)
Current level of study	
Year 3 (300 level)	48 (47.1)
Year 4 (400 level)	54 (52.9)
Educational background	
Secondary school Technical	72 (70.6)
college Polytechnic	0 (0)
education	30 (29.4)

Actual vs Expected score: The grading system adopted in Nigerian universities is regulated by the National Universities Commission, and are categorised into five namely: A (70 -100), B (60 – 69), C (50 - 59), D (45 – 49) and F (0 – 44). Students were asked to provide actual and expected scores in their last design course. None of the students anticipated or received a F. None of them anticipated a D but three (2.9%) were awarded a D. Only nine (8.8%) students expected a C but 27 (26.5%) actually scored a C, 24 (23.5%) anticipated a B whereas 57 (55.9%) had it. The majority of the students, 67.6% anticipated receiving an A grade however, only 14.7% of them actually had an A. This indicates that students' expectations sometimes do not represent or match their actual performance.

Reaction to design grade: Students' reactions to the grades awarded them in their last design course was measured by asking them to respond to a list of possible responses adopted from the literature. Some of the students (35.3%) felt their efforts had not been rewarded because they did not receive their anticipated or expected grades while 17.6% were motivated and encouraged. These students could be those whose anticipated grade was their actual grade. Few students (2.9%) attempted to quit the course as result of low grades, 23.5% accepted the result and started preparations for the next design course, 14.7% did not bother about their grade since they did not fail the course while 5.9% were bothered about their grade but were scared to request a re-mark of their design (see Table 3). The reasons for being apprehensive about asking for a re-mark may have been influenced by

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factors including student-lecturer relationships, procedures involved, and students' experience.

Table 3: Reactions to grades

Reactions	Frequency (%)
I felt my efforts have not been rewarded	36 (35.3)
I was motivated and encouraged	18 (17.6)
I was tempted to quit the course	3 (2.9)
I accepted the result and started preparations for the next design course	24 (23.5)
I was not bothered in as much as I didn't fail	15 (14.7)
I was bothered but scared to request/call for a re-mark	6 (5.9)

Factors affecting design grades: Table 4 shows the factors affecting students' grades in design courses. These have been categorised into three namely: student-based factors, course factors, and tutor-based factors. Student-based factors include their academic background, drawing/design skills and abilities, social life and commitment to learning. The course factors are course contents and requirements while the tutor-based factors are grading system, style of teaching, tutor's instructions, direction and support as well as design studio facilities. The students were asked to rate their level of agreement with statements about the factors on a five point Likert scale with values ranging from 1 to 5 (1 = strongly disagree and 5 = strongly agree). The average weight for each factor was calculated and presented in Table 4. The students were of the opinion that the grading system (3.94) adopted by their tutors was the factor that most probably affecting their grades. This finding is similar to that reported by Umbach and Wawrzynski (2005), Lo and Olin, (2009a, 2009b), Lo and Prohaska (2009) in their studies that tutors play important role in students' satisfaction. Next was the style of teaching (3.82), tutor's instructions, direction and support (3.65), and studio facilities provided (3.59). The factor with the least influence was seen as social life.

Table 4: Factors affecting design grades

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Weighted average
Academic background	6 (5.9%)	45 (44.1%)	6 (5.9%)	39 (38.2%)	6 (5.9%)	2.94
Drawing/design skills or abilities	6 (5.9%)	18 (17.6%)	9 (8.8%)	57 (55.9%)	12 (11.8%)	3.50
Social life	12 (12%)	48 (47%)	21 (20.5%)	18 (17.6%)	3 (2.9%)	2.53
Commitment to learning	6 (5.9%)	33 (32.4%)	18 (17.6%)	39 (38.2%)	6 (5.9%)	3.06
Course contents and requirements	3 (2.9%)	24 (23.5%)	27 (26.5%)	45 (44.1%)	3 (2.9%)	3.21
Grading system adopted	6 (5.9%)	3 (2.9%)	9 (8.8%)	57 (55.9%)	27 (26.5%)	3.94
Style of teaching	6 (5.9%)	0 (0%)	18 (17.6%)	69 (67.6%)	9 (8.8%)	3.82
Tutor's instructions, direction, and support	3 (2.9%)	3 (2.9%)	30 (29.4%)	57 (55.9%)	9 (8.8%)	3.65
Design studio's facilities and amenities	3 (2.9%)	3 (2.9%)	42 (41.2)	39 (38.2%)	15 (14.7%)	3.59

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Students' satisfaction: The students were asked to rate their satisfaction with their performance, course grade, design coordinators and tutors. Design coordinators refer to lecturers in charge of design courses for that semester while tutors are invited panel members to assess designs/drawings at the end of the semester. As shown in Table 5, the students were not very satisfied (2.03) with the tutors but they were somewhat satisfied with their own performance (2.91). It is interesting to note that students were not very satisfied with their tutors perhaps they see them as originators of their low grades rather than learning facilitators. A Pearson correlation was computed to assess construction students' satisfaction with their tutors based on and their grades (expected and actual). There was a positive correlation between the variables, $r = 0.700$ (expected score), 0.861 (actual score), $n = 102$, $p < 0.001$. Based on this result, the null hypothesis (there is no significant difference in construction students' level of satisfaction with their tutors based on their grades) is rejected. This implies that students are not satisfied with their tutors whenever their expected grade is not the same with their actual grade.

Table 5: Students' satisfaction

	Not at all satisfied	**Not so satisfied**	**Somewhat satisfied**	**Very satisfied**	**Extremely satisfied**	**Weighted average**
Course grade	21 (20.6%)	45 (44.1%)	21 (20.6%)	15 (14.7%)	0 (0%)	2.29
Performance	0 (0%)	39 (38.2%)	33 (32.4%)	30 (29.4%)	0 (0%)	2.91
Design coordinators	3 (2.9%)	51 (50)	42 (41.2%)	6 (5.9%)	0 (0%)	2.50
Tutors/Jurors	39 (38.2%)	33 (32.4%)	24 (23.5%)	3 (2.9%)	3 (2.9%)	2.03

Table 6: Pearson correlation

		Students_ satisfaction	**Expected_ score**	**Actual_ score**
Students_satisfaction	Pearson Correlation	1	.700**	.861**
	Sig. (2-tailed)		.000	.000
	N	102	102	102
Expected_score	Pearson Correlation	.700**	1	.803**
	Sig. (2-tailed)	.000		.000
	N	102	102	102
Actual_score	Pearson Correlation	.861**	.803**	1
	Sig. (2-tailed)	.000	.000	
	N	102	102	102

**. Correlation is significant at the 0.01 level (2-tailed).

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Factors affecting the grading system: In order to further understand how the grading system affected their grades, students were asked to rate their level of agreement with the factors affecting the grading system. Table 7 shows their responses. The most highly ranked factor affecting the grading system is different tutors assessing each group of students (4.18). Following this are the tutor's personal approach to design (4.15) and inconsistent marking (4.03). The least ranked factor was students' inability to express themselves during presentations (3.42). Some of the students agreed that their inability to meet submission requirements (3.59) could also be responsible for their low grades while others (3.88) felt that the tutors favoured those who received high grades.

The study sought students' opinions on how to improve tutor's assessment. Via an open-ended question in the questionnaire, students gave several suggestions. These included the use of continuous assessment instead of one-off marking, communicating the grading parameters to all students, allowing more time for students to express their ideas, absolute fairness to all students, and use of a standard assessment scale. Chief amongst these suggestions was that the same tutors assessed the work of all students using the same assessment scale rather than for several tutors to be involved. It is a common practice in most schools of architecture in Nigeria to divide students into groups and assign different tutors to grade each group. This study reveals that students are no longer comfortable with the grading system and hence, there is a need for a review of the system.

Table 7: Factors affecting the grading system

	Strongly disagree	**Disagree**	**Neutral**	**Agree**	**Strongly agree**	**Weighted average**
Different tutors assessing each group of students	6 (5.9%)	0 (0%)	9 (8.8%)	42 (41.2%)	45 (44.1%)	4.18
Tutor's personal opinion or approach to design	3 (2.9%)	6 (5.9%)	0 (0%)	57 (55.9%)	36 (35.3%)	4.15
Tutor's inconsistent markings	3 (2.9%)	3 (2.9%)	9 (8.8%)	60 (58.8%)	27 (26.5%)	4.03
Tutor's personal impression of the student	3 (2.9%)	12 (11.8%)	6 (5.9%)	57 (55.9%)	24 (23.5%)	3.85
Students' inability to express themselves (poor presentation)	0 (0%)	21 (20.6%)	27 (26.4%)	48 (47.1%)	6 (5.9%)	3.42
Students' inability to meet submission requirements	0 (0%)	3 (2.9%)	39 (38.2%)	57 (55.9%)	3 (2.9%)	3.59
Favouritism	3 (2.94%)	3 (2.94%)	15 (14.7%)	63 (61.8%	18 (17.6%)	3.88

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CONCLUSION

This study has assessed the factors affecting students' satisfaction with grades in design courses revealing three categories of factors namely: students-based factors, course factors and tutor-based factors. Student-based factors were further categorised into their academic background, drawing/design skill, commitment to learning and social life. Course factors were categorised based on the course content and requirements while tutor-

based factors included the grading system adopted, style of teaching, studio facilities, and tutor's instructions, direction and support. The paper revealed a strong and positive correlation between students' satisfaction with their tutors and grades awarded them. It also identified the grading system adopted as the main factor affecting students' satisfaction with grades. Most students felt their efforts had not been rewarded and because of this, they were not very satisfied with their tutors. However, they were satisfied with their own performance. It was also revealed that different tutors assessing different groups of students affected the consistency with which grading systems were applied. The students suggested that the same tutors assessed the work of all students as a possible way of improving the grading system. The results discussed in this study may not be generalizable to other profession in the AEC sector because only year 3 and
4 architecture students in one university were consulted. This study is significant as it draws the attention of tutors to students' concerns about their grading system. Since students no longer feel comfortable with the grading system, it is recommended that tutors or course coordinators review it and if possible develop an all-inclusive grading system. Future research work may include other students across all levels and universities.

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THE IMPACT OF INDIVIDUAL BELIEFS AND EXPECTATIONS ON BIM ADOPTION IN THE AEC INDUSTRY

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ABSTRACT

The use of Building Information Modelling (BIM) in the construction industry has been growing steadily during the last decade, yet there is a continues resistance to its adoption, due to some users' unawareness of BIM benefits. BIM adoption is associated with an individual's willingness towards using it which is driven by individual beliefs and expectations of BIM use consequences. Technology Acceptance Model (TAM) identified perceived usefulness (PE) and perceived ease of use PEOU as variables to inform us with user's mind-set and intentions towards the use of technology. This research proposes a conceptual framework for exploring and measuring individual willingness level for adopting BIM, based on individual beliefs and expectations of BIM use consequences in construction industry. The research conducted literature review on technology acceptance and use theories from IS mainstream to identify the individual beliefs and expectations variables, then conducted a literature review on case studies researches that directly applied TAM, to contextualize the variables into BIM in construction environment. The research outcome identified the individual willingness constructs to accept and use BIM: performance expectancy, effort expectancy, social conditions, facilitating conditions, and attitude towards using.

Keywords: Building Information Modelling, BIM adoption, individual believes and expectations, Technology Acceptance Model, user satisfaction.

INTRODUCTION

Building Information Modelling (BIM) has been promoted as the ultimate solution for the coordination problems, mainly because it is considered as the central repository for information, and covers the entire cycle of the project from its conception up through demolition (Howard et al. 2017). Though it is agreed between researchers and practitioners that BIM has many potential benefits it is still unclear why BIM is not adopted,

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accepted and used significantly in the construction industry (Lee et al. 2013).

Studies in digital construction showed that resistance (Davis & Songer 2008; Brewer & Gajendran 2012) and other socio-techno behaviours may raise during early stages of adoption: e.g. stubbornness of employees about keeping the old CAD ways of working alive (Morlhon et al. 2014; Tulenheimo 2015). The resistance happens because of even user's unawareness or un-satisfaction of BIM benefits and advantages (Arayici et al. 2011Brewer & Gajendran 2012;Lee et al. 2013).

The acceptance to adopt BIM technology is not a simple case of approval or rejection, various researchers have proposed diverse factors that can influence technology adoption and acceptance. For instance, Davies & Harty (2013) identified that the individual beliefs and expectations regarding the technology consequence use have important role in successful adoption. Deutsch et al. (2011) discussed three change drivers due to technology adoption as people, business, and the technology itself. Furthermore, Venkatesh et al. (2003) attested that performance expectancy, effort expectancy, social influence and facilitating conditions determine the rate of technology acceptance which are subject to people's attitudes towards technology use. In addition, the technology acceptance model proposed that the individual's behavioural intention to use new technology is determine by two beliefs which are perceived usefulness and ease of use. Also, Jacobsson & Linderoth (2012) confirmed that occupational skills and nature of work task influence ICT technology adoption. Based on these facts, there is an indication that the acceptance of BIM technology in the Architectural Engineering and Construction (AEC) industry can possibly be influenced by individual prerequisites. Therefore, this study aims to explore the influence and impact of individual beliefs and expectations on individual's willingness to adopt BIM and thereby true implementation in the industry.

LITERATURE REVIEW

Literature review was conducted in two broad areas; theories of technology adoption and BIM adoption in construction. The former informed the factors critical to the adoption of any technology whist the latter investigated how these theories apply in the context of BIM adoption in the construction industry. Among the technologies adoption theories reviewed, two heavily applied ones are discussed below, namely: Technology Acceptance Model (TAM) and Unified Theory of Acceptance and Use of Technology (UTAUT)

Technology Acceptance Model (TAM)

Technology Acceptance Model (TAM) was introduced by Davis (1989). TAM is an adoption of Theory of Reasoned Action (TRA) and Theory of

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Planned Behaviour (TPB), specifically tailored for user acceptance of Information Systems (IS). The purpose of TAM is to explain individuals' acceptance of new technologies and their related behaviours. In TAM, Perceived Usefulness (PU) and Perceived Ease of Use (PEOU) are the key constructs of IS acceptance behaviour. As shown in Figure 1, TAM proposes external variables that directly affect PU and PEOU, which consequently affect indirectly the attitude towards the use (ATT) of a technology, and ultimately leads to the actual use of the technology by influencing PU and PEOU.

TAM proposes that the individual's behavioural intention to use a new technology is determined by two beliefs: perceived usefulness, defined as the extent to which a person believes that using the system will enhance his or her job performance; and perceived ease of use, defined as the extent to which a person believes that using the system will be free of effort. TAM assumes that the effects of external variables on intention to use are mediated by perceived usefulness and perceived ease of use.

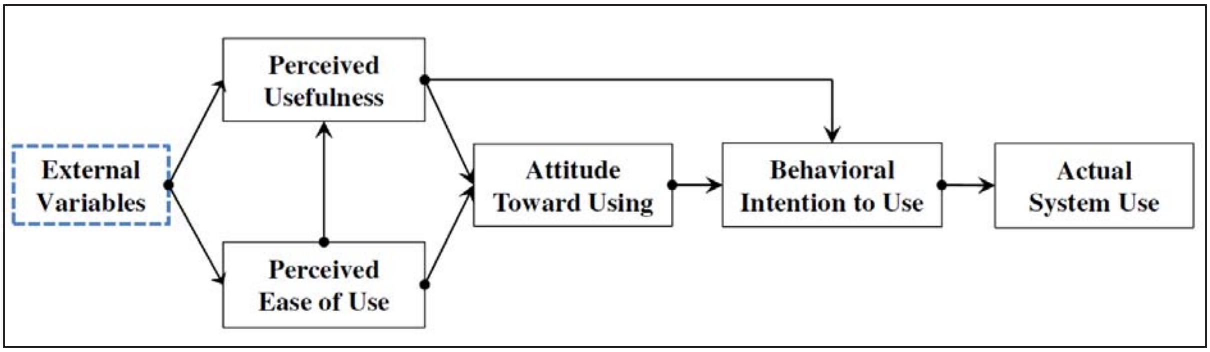

Figure 1 Technology Acceptance Model (TAM)

(Source: Davis 1989)

Venkatesh and Davis (2000) extended TAM into TAM2 by adding subjective norms as an additional predictor of the behavioural intention, in addition to concluding the definition of external variables (see Figure 2). Further research on TAM led to the development of TAM3 by Venkatesh & Bala (2008)

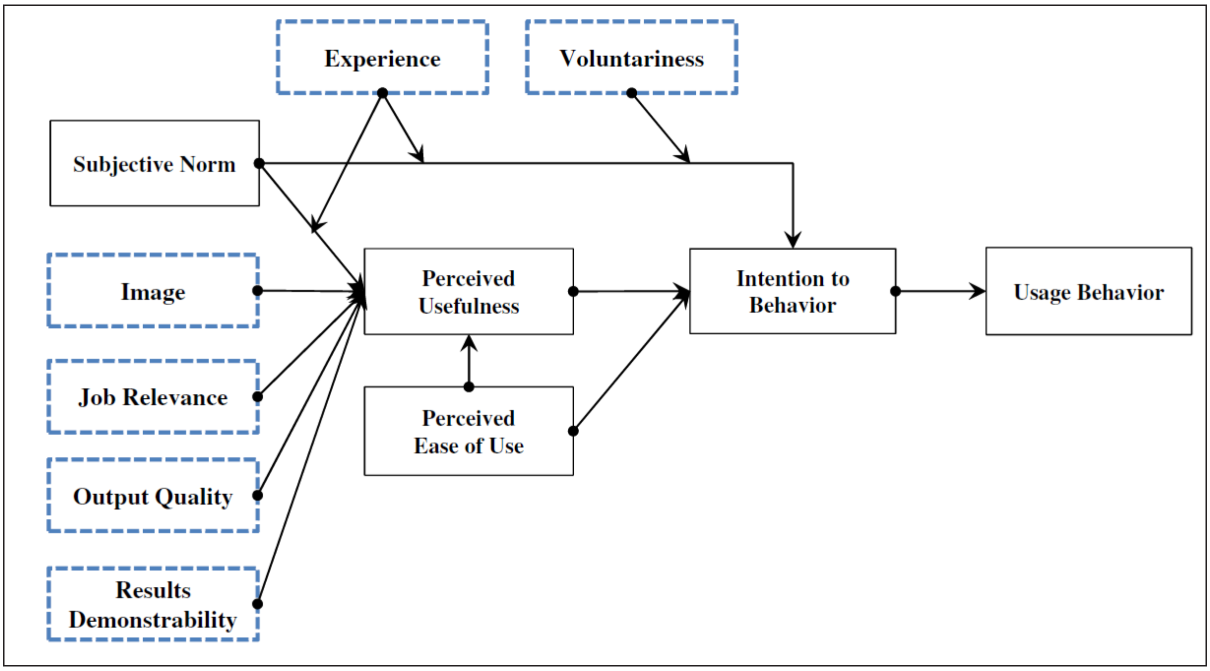

Figure 2 Technology Acceptance Model 2 (TAM2)

(Source: Venkatesh & Davis 2000)

Unified Theory of Acceptance and Use of Technology (UTAUT)

Venkatesh et al. (2003) proposed the Unified Theory of Acceptance and Use of Technology (UTAUT) based on eight technology acceptance and behavior-related theories: Technology Acceptance Model (TAM/TAM2) (Davis 1989), Theory of Reasoned Action (TRA) (Fishbein & Ajzen 1975), Motivation Model (MM) (Davis et al. 1992), Theory of Planned Behaviour (TPB) (Ajzen 1991), Model of Personal Computing Utilization (MPCU) (Thompson et al. 1991), Innovation Diffusion Theory (IDT) (Moore & Benbasat 1991), and Social Cognitive Theory (SCT) (Compeau et al. 1999).

Venkatesh et al. (2003) proposed and defined four constructs of UTAUT (see Figure 3): (1) Performance Expectancy (also referred as Perceived Usefulness); the degree to which an individual believes that using the technology will help him or her to achieve improvements in job performance, (2) Effort Expectancy (also referred as Perceived Ease of Use); the degree of ease linked with the use of the technology, (3) Social Influence (also referred as subjective Norms); the degree to which an individual perceives that others believe he or she should use the new technology, and (4) Facilitating Conditions, the degree to which an individual believes that an organizational and technical infrastructure exists to support the use of the technology.

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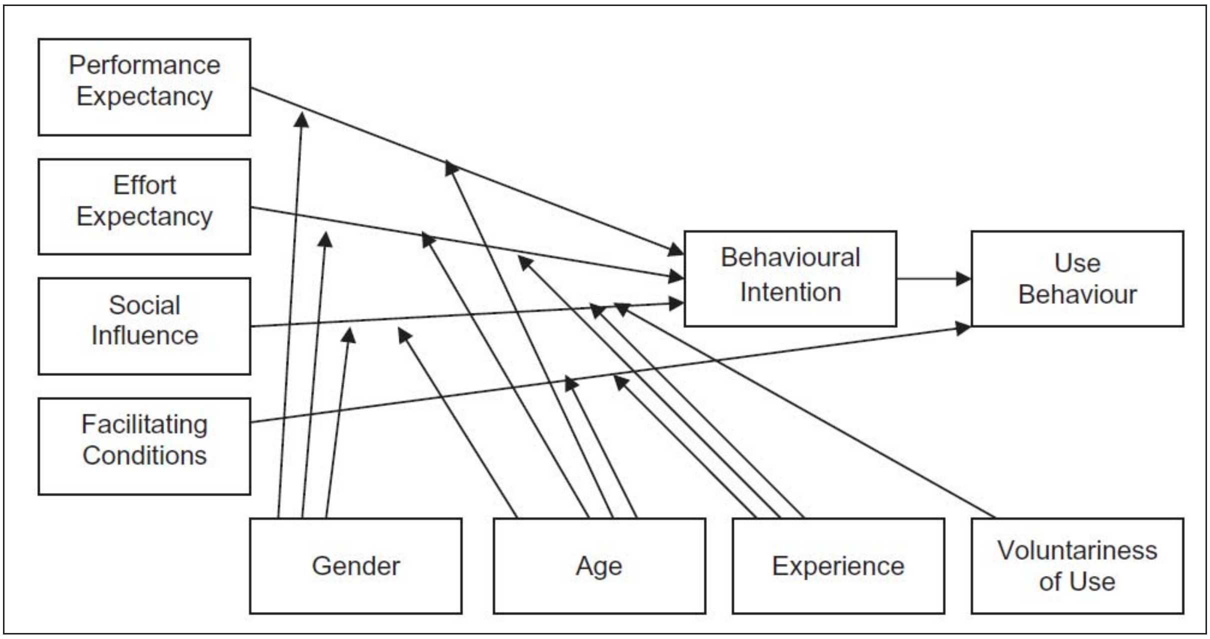

Figure 3 Unified Theory of Acceptance and Use of Technology (UTAUT) (Source: Venkatesh et al. 2003)

BIM ACCEPTANCE IN THE CONSTRUCTION INDUSTRY

The above theories have been applied by few researchers to investigate BIM adoption in the construction industry, which are discussed below.

In the South Korean construction industry context, a BIM Acceptance Model (BAM) was proposed by Lee et al. (2013b). BAM identified 28 key factors and used them as TAMs external variables. The factors were classified into; compatibility, output quality, collective efficiency, organizational innovativeness, self-efficacy, personal innovativeness, top management support, internal pressure, and external pressure. The research concluded that perceived usefulness has a significant impact on individual intent to accept BIM, also concluded that organizational competency has the most significant impact on perceived ease of use.

Davies and Harty (2013a) explored the individual beliefs about BIM consequence use in large construction contracting organizations in the United Kingdom. The examined the relationship between the salient individual-level variables; performance, effort, social influence, facilitating conditions, compatibility, and attitude towards using the technology. The outcome showed that there is a strong relationship between the expectations that BIM would enhance job performance (user's perception) and the expectation that BIM use was compatible with preferred and existing ways of working (facilitating conditions).

Wang and Song (2017)examined the influence of five variables on BIM user satisfaction in the AEC industry. Three of these variables were from

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TAM, which are perceived benefits, perceived ease of use, and attitude, in addition to two management variables: top management support, and management by objective. The results showed that perceived usefulness, top management support and management by objective are significantly associated with BIM user satisfaction, and the influence of management by objective on BIM user satisfaction is stronger than top management support and perceived usefulness. Also, perceived ease of use and attitude have a significant influence on perceived usefulness.

Howard et al. (2017) directly used UTAUT to explore the individual perceptions towards working with BIM in the UK AEC industry. The study extended UTAUT with extra variables: gender, age, and experience. The results revealed that performance expectancy does not directly affect the behavioural intention, suggesting that BIM is perceived as an unrewarded addition to existing work processes. The research finding highlights the need to redefine the strategies, policies, and incentive schemes to advance the acceptance of BIM in the UK.

Merschbrock & Nordahl-Rolfsen (2016) directly used TAM to examine ironworkers' acceptance of using BIM for facilitating on-site placement of reinforcement bars with a sophisticated virtual model, replacing the traditional way of using shop-drawings for fabrication and placement of the reinforcement bars, for the Oslo new airport terminal project in Norway. The findings showed that the workers perceived the virtual model as more beneficial over the paper-based shop drawings.

The above mentioned researches explored the influence of users' perception on BIM acceptance, and the effect of external variables, such as; top management role, gender, age, experience, beliefs and expectations, efficiency compatibility, output quality, collective efficiency, organizational innovativeness, self-efficacy, and personal innovativeness. Moreover, both user satisfaction and perceived usefulness emphasise on the individuals' perception of the new technology; their beliefs and expectations on how the new technology will affect their work in addition to an embedded assumption that their positive expectations about using BIM will result in benefits (positive impact) for the organization. Aligning users' perception with their expectations and believes for the technology adoption will reveal the satisfaction level. These factors are significant for understanding BIM acceptance and use (Davies & Harty 2013).

Information System stream identified the three phases for innovation adoption in business: pre-adoption phase, actual adoption phase, and post-adoption phase. The above mentioned researches mainly discuss the user's acceptance for BIM in actual adoption phase. The proposed willingness framework will be checking the user's mindsets in pre-adoption phase to predict users' reactions and behaviors before adoption, which is considered the research knowledge gap.

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Performing “willingness health-check” for employee’s readiness for BIM adoption, will be valuable for organizational management in decision making and planning proper strategies for enhancing BIM adoption.

FRAMEWORK OF BIM ADOPTION WILLINGNESS AND BEHAVIOUR

Figure 4 illustrates a new framework that is developed to address the knowledge gap identified above. The framework draws on technology acceptance and use theories mentioned in the literature review to measure the individual willingness level of using BIM, and consequently the reflected actual usage behaviour. Measuring the willingness level will reveal the behavioural intention whether it was resistance (negative level) or motivation (positive level). Understanding the variables that affect the level of willingness e will assist in controlling BIM adoption behaviours.

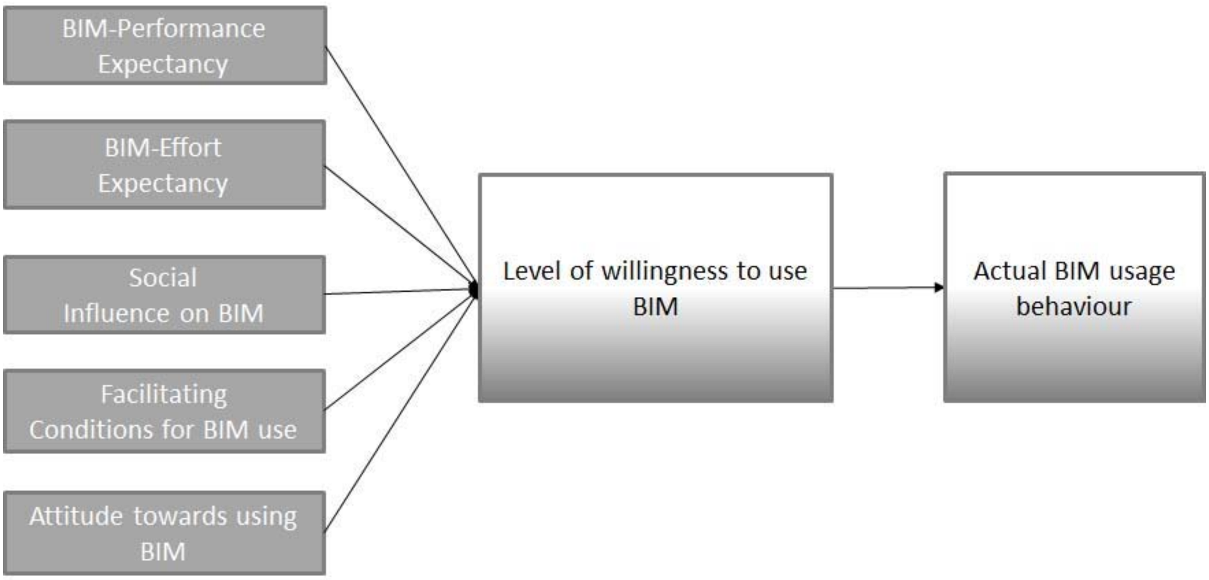

Figure 4 the research conceptual framework

The IS literature clarified how perceived usefulness PU and perceived ease of us PEOU form the individual perception of technology use, and consequently the individual expectations for performance expectation PE and effort expectation EE. UTAUT identified social influence SI and facilitating condition FC as influential variables for individual beliefs for the technology consequence use. See Table 1 for UTAUT constructs referenced to their original technology acceptance and theories.

Table 1 UTAUT constructs

UTAUT constructs	**Corresponding theory title**	**Corresponding technology aceptance theory**
Performance Expectancy	Perceived Usefulness	Technology Acceptance Model (Davis 1989)
Effort Expectancy	Perceived Ease of Use	Technology Acceptance Model (Davis 1989)
Social Influence	Social Factors	Model of Personal Computing Utilization

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		(Thompson et al. 1991)
Facilitating Condition	Facilitating Conditions	Model of Personal Computing Utilization (Thompson et al. 1991)
Facilitating Condition	Compatibility	Innovation Diffusion Theory (Moore & Benbasat 1991)
Attitude Toward using Technology	Attitude Toward Behaviour	Technology Acceptance Model (Davis 1989)

The conceptual framework contextualises the UTAUT constructs and their item wording to BIM. The conceptual framework postulates that the degree of actual BIM use in one's job role is dictated by his/her level of willingness to adopt BIM, which in turn is influenced by five factors, such as: (1) BIM performance expectance (BPE), (2) BIM effort expectance (BEE), (3) social influence on BIM (SIB), (4) facilitating condition for BIM use (FCB), and (5) attitude towards using BIM (ATTB). Table 2 below shows the contextualised variables definitions and the item wording originated from the original theories. The last column of the table lists questions that can help to measure each of the construct with construction professionals.

Table 2 Constructs description and item wording

Vari.	**Scale Descreption**	**Scale Item wording**
BPE	The degree to which a person believes that using a particular system would enhance his or her job performance (Davis 1989).	1. Using BIM in my job would enable me to accomplish tasks more quickly. 2. Using BIM would improve my job performance. 3. Using BIM in my job would increase my productivity. 4. Using BIM would enhance my effectiveness on the job. 5. Using BIM would make it easier to do my job. 6. I would find the system useful in my job.
BEE	The degree to which a person believes that using a system would be free of effort (Davis 1989).	1. Learning to operate BIM would be easy for me. 2. I would find it easy to get BIM to do what I want it to do. 3. My interaction with BIM would be clear and understandable. 4. I would find BIM to be flexible to interact with. 5. It would be easy for me to become skilful at using BIM. 6. I would find BIM easy to use.
SIB	The individual's internalization of the reference group's subjective culture. and specific interpersonal agreements that the individual has made with others, in specific social situations (Thompson et al. 1991).	1. I use BIM because of the proportion of co-workers who use the system. 2. The senior management of this business has been helpful in the use of BIM. 3. My supervisor is very supportive of the use of BIM for my job. 4. In general, the organization has supported the use of BIM.
FCB	Objective factors in	1. Guidance was available to me in the selection of BIM.

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	the environment that observers agree make an act easy to do. including the provision of computer support (Thompson et al. 1991).	2. Specialized instruction concerning BIM was available to me. 3. A specific person (or group) is available for assistance with BIM difficulties.
	The degree to which an innovation is perceived as being consistent with existing values, needs. and experiences of potential adopters (Moore & Benbasat 1991).	4. Using BIM is compatible with all aspects of my work. 5. I think that using BIM fits well with the way I like to work. 6. Using BIM fits into my work style.
ATTB	An individual's positive or negative feelings about performing the target behaviour (Davis 1989).	1. I have control over using BIM. 2. I have the resources necessary to use BIM. 3. I have the knowledge necessary to use BIM. 4. Given the resources, opportunities and knowledge it takes to use BIM, it would be easy for me to use BIM. 5. BIM is not compatible with other systems I use.

CONCLUSION

This research proposed a conceptual framework for measuring the level of willingness for using BIM, based on individual beliefs and expectations variables: performance expectance, effort expectance, social influence, facilitating condition, and attitude toward using BIM. Accordingly, willingness level will be reflected on the actual BIM usage behaviour whether it is motivated or resistance behaviour.

To verify the conceptual framework, a questionnaire will be created based on the item desertion shown in Table 2 above, and will be sent to BIM users in Australian construction organizations.

Understanding employees' behaviours based on willingness level will be valuable and beneficial for organizational management for different purposes: assist management in putting implementation strategies, reduce the implementation cost and financial risk, will guide in setting BIM benefit realisation context for users, and finally it will help management to work on their motivation schemes or incentives.

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TRAINING TRANSFER AS THE RESULT OF RATIONAL DECISION-MAKING PROCESS

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ABSTRACT

Employee training is delivered as a part of most human resource development programs because organizations expect training courses will enhance their employees' performance. However, training may not lead to improved work performance if training transfer does not occur. The lack of training transfer in practice has long been considered as a critical problem. Also, previous theoretical models of training transfer cannot fully explain this phenomenon. As an attempt to solve the training transfer problem, this paper provides a literature review on training transfer and proposes a conceptual model grounded on the Theory of Planned Behaviour.

Keywords: training transfer, models of training transfer, the Theory of Planned Behaviour, literature review

INTRODUCTION

Human capital plays an important role in organizational success so developing adequate human resource development (HRD) programs is an essential strategy for construction companies (Egbu, 2004). Employee training is delivered as a part of most HRD programs since training courses are designed to provide individuals with skills and knowledge that they may use at work (Blundell et al., 1999). Construction firms expect that the acquisition of necessary skills and knowledge will improve their employees' performance, which in turn contributes to organizational success. However, there has been a concern about the effectiveness of training in construction (Gann and Senker, 1998; Wilkins, 2011). Also, even with effective training, which means employees successfully learn and retain the training content, improved work performance cannot be achieved if they do not use their learned skills and knowledge at work. The extent to which trainees apply their acquired skills and knowledge in practice is known as training transfer (Baldwin and Ford, 1988).

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Unfortunately, the lack of training transfer is a common problem in various industries (Blume et al., 2010), including the construction industry (Choudhry and Fang, 2008). Because organizations spend billions of dollars annually on employee training (Grossman and Salas, 2011), it can be considered as wasteful if the return of training investment is not fully realized. Despite the importance of training transfer, little research has been conducted to investigate this phenomenon in the construction context (Namian et al., 2016). To gain a better understanding of training transfer, this paper reviews the literature on training transfer and proposes an explanatory model that can be subject to further empirical testing.

LITERATURE REVIEW

Since the 1950s, the problem regarding training transfer has been widely recognized as researchers found that skills and knowledge acquired from employee training often failed to transfer into work performance (Baldwin and Ford, 1988). Before 1988, most studies of training effectiveness and transfer sought to identify specific factors or separate sets of factors which were linked to training transfer. However, in a ground-breaking publication in 1988, Baldwin and Ford (1988) introduced a system model of the training transfer process. Since then, training transfer has been commonly understood as being influenced by a system of factors (Holton III et al., 2000). Given this major shift in thinking, this literature review only includes training transfer models developed since 1988.

Baldwin and Ford (1988)'s model of the transfer process was proposed based on a comprehensive review of previous studies published from the 1950s to the 1980s. The model indicates that factors affecting training transfer could be divided into three sets: trainee characteristics, training design, and the work environment.

Five years later, Rouiller and Goldstein (1993) introduced a model indicating that training transfer is affected by the prevailing transfer climate at the workplace. Within this model, transfer climate is considered as an individual's perception of the extent to which the work environment facilitates or inhibits their application of learned skills and knowledge.

Based on Rouiller and Goldstein's work, Thayer and Teachout (1995) introduced a more comprehensive model of training transfer. Apart from the impact of transfer climate, this model suggests that individual characteristics play a crucial role in the success of training transfer.

Later, Holton III et al. (2000) developed and validated an instrument called the Learning Transfer System Inventory (LTSI), which introduces many individual characteristics, as well as factors related to training design and the work environment as determinants of training transfer. The LTSI recognizes the central role of motivation in facilitating training transfer, and this positioning of motivation as playing a key role has become commonly accepted (Gegenfurtner et al., 2009).

TRAINING TRANSFER AS THE RESULT OF RATIONAL DECISION-MAKING PROCESS

Previous models of training transfer provide many factors potentially affecting the application of learned skills and knowledge in practice. However, Cheng and Hampson (2008) emphasized that those models may not be sufficient to fully explain the training transfer phenomenon because of contradictory and unexpected findings arising from many empirical studies. Gegenfurtner et al. (2009) argued a flaw inherent in most training transfer models is that they oversimplify motivation. The term motivation is multidimensional, but most models do not reflect this multidimensionality. Thus, further research needs to be conducted to better understand training transfer from the motivational point of view. Baldwin et al. (2009) suggested that training transfer should be considered as an issue of personal choice. Hence, rather than attempting to identify factors affecting training transfer, it is arguably helpful to find answers to the underlying question: why do trainees choose to apply or not to apply acquired skills and knowledge at work?

Training transfer is defined as the extent to which trainees apply acquired skills and knowledge in practice. Although training transfer is a complex phenomenon, the application of learned skills and knowledge at work is a specific human action. Hence, training transfer can be considered as the result of individual cognitive selection of whether to perform this action or not. If we assume that the transfer action is performed as the result of trainees' rational decision-making processes, we can explain why they choose to do so by adapting the Theory of Planned Behaviour (TPB), which has been applied to predict a wide range of actions (Godin and Kok, 1996). However, little research has been conducted to explain training transfer based on the TPB's perspective (Cheng and Hampson, 2008).

THE THEORY OF PLANNED BEHAVIOUR

The TPB assumes that an individual's choice to perform or not to perform an action is rational, and this decision making is based on information they perceive from their environment (Ajzen, 1991). The theory suggests that intention is the direct antecedent of behaviour. In turn, intention is determined by three components:

- attitude toward the behaviour,
- subjective norms, and
- perceived behavioural control.

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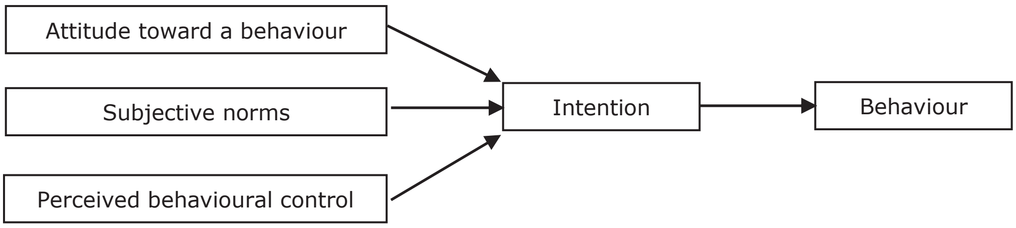

Figure 1: The Theory of Planned Behaviour

(Source: Ajzen, 1991)

According to Ajzen (2002a), attitude toward a behaviour often involves two components:

- an instrumental component representing the extent to which an individual values consequences (e.g. benefit or rewards) when performing the behaviour in question, and

- an experiential component reflecting the extent to which this individual takes pleasure in or enjoy performing the behaviour.

The first component refers to extrinsic motivation which indicates the goal-driven reasons for performing a certain behaviour (Ryan and Deci, 2000). The second component refers to intrinsic motivation that focuses on the pleasure an individual derives as a result of performing a behaviour (Ryan and Deci, 2000).

Within the TPB, subjective norms are conceptualized as injunctive norms (Ajzen, 1991). However, there are two separated types of norms: injunctive norms and descriptive norms (Cialdini et al., 1990). Injunctive norms refer to social pressures to perform a behaviour based on an individual's perception of what other people want them to do. Descriptive norms refer to social pressures to perform the behaviour based on the individual perception that other people also do so. Because of the absence of descriptive norms in the TPB, Armitage and Conner (2001) argued that subjective norms are the weakest determinants of intention. Therefore, Ajzen (2002a) recommended including both types of norms when adapting or using the TPB to explain a particular behaviour.

According to Ajzen (2002b), perceived behavioural control involves two aspects:

- an aspect reflecting an individual's perception of the ease/difficulty of performing an action or the likelihood that the action can be performed, and

- an aspect indicating the individual perception that they have control over the action.

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In other words, perceived behavioural control is determined by perceived self-efficacy and perceived controllability.

A TRAINING TRANSFER MODEL BASED ON THE THEORY OF PLANNED BEHAVIOUR

The TPB indicates that intention to perform an action is the direct antecedent of this behaviour. If training transfer is considered as a particular behaviour, its direct antecedent will be intention to transfer. Ajzen (1991) argued that intention refers to a motivation factor that affects behaviour. Hence, intention to transfer and motivation to transfer are synonymous in the context of the TPB. Motivation to transfer has widely been considered as the central factor influencing training transfer (Baldwin and Ford, 1988; Holton III et al., 2000; Bunch, 2007). Also, the TPB suggests that motivation to transfer is determined by attitude toward, subjective norms of, and perceived behavioural control over training transfer.

Factors affecting attitude toward training transfer

When considering the specific action of training transfer, attitude toward this behaviour can be defined as a trainee's overall evaluation of applying acquired skills and knowledge at work. The evaluation entails a consideration of the likely outcomes of performing this behaviour. Previous research has found that factors affecting intrinsic motivation such as perceived enjoyment or satisfaction when performing training transfer have a positive impact on motivation to transfer (Smith et al., 2008). When employees perceive that they feel pleasure in or enjoy using new skills and knowledge, they are likely to develop the willingness to perform transfer action. Also, factors influencing extrinsic motivation such as improving work performance, achieving rewards, or avoiding punishment as the results of performing training transfer have been widely found to predict motivation to transfer (Bates and Holton III, 2004; Devos et al., 2007).

Factors affecting subjective norms of training transfer

Previous empirical studies have proposed that injunctive norms such as perceived organizational learning culture and social support play a crucial role in determining motivation to transfer. Organizational learning culture reflecting beliefs and values about the importance or benefit of applying learned skills and knowledge has been identified as a factor affecting transfer motivation (Bates and Holton III, 2004; Egan et al., 2004). If employees perceive that their organizations encourage them to apply new skills and knowledge in practice, they are likely to do so. At work, supervisor support may influence employees' motivation to use acquired skills and knowledge (Bates and Holton III, 2004; Kirwan and Birchall, 2006). When receiving supervisor encouragement, guidance, or goal-

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setting regarding using learned skills and knowledge, employees would develop the perception that their supervisors want them to transfer training. Additionally, peer support is even more effective than supervisor support regarding facilitating motivation to transfer (Bates and Holton III, 2004; Devos et al., 2007). When obtaining peer encouragement or support regarding using new skills and knowledge, employees may perceive that their colleagues expect them to do so. Furthermore, feedback from supervisors and peers about how well employees are applying learned skills and knowledge may have an impact on motivation to transfer (Bates and Holton III, 2004; Kirwan and Birchall, 2006). This type of feedback can make employees recognize that most people at their workplace expect them to perform training transfer.

Additionally, descriptive norms may have an impact on motivation to transfer. If employees observe that their colleagues do not use learned skills and knowledge (team/group resistance to change), this can discourage their willingness to transfer training (Devos et al., 2007). On the contrary, if employees perceive that their peers apply new skills and knowledge, they may be more likely to do the same thing.

Factors affecting perceived behavioural control over training transfer

Post-training self-efficacy has long been considered as an antecedent of motivation to transfer (Noe and Wilk, 1993; Axtell et al., 1997; Chiaburu and Lindsay, 2008). If employees think that applying acquired skills and knowledge is easy to do and believe this action can be done, they may be motivated to perform training transfer. However, if employees do not believe they are able to use learned skills and knowledge, this perception may negatively affect their willingness to perform it. Additionally, even with high self-efficacy, employees may not use acquired skills and knowledge if their workplace provides insufficient enabling tasks or resources (e.g. equipment, materials, supplies) for them to do so. Hence, the opportunity to transfer training is a crucial factor influencing transfer motivation (Bates and Holton III, 2004). Also, employees may perceive themselves to have more control over training transfer when they receive adequate social support (e.g. supervisor support, peer support, feedback).

The prerequisite of training transfer is training. Without sufficient understanding and retention of the training content, employees cannot perform their expected transfer action. On the contrary, learned skills and knowledge provide employees with an opportunity to transfer training. Previous research indicated that trainees who successfully acquire the training contain are likely to develop their willingness to perform transfer action (Facteau et al., 1995). In other words, the success of training may have a positive impact on trainees' motivation to transfer. Thus, training should be designed and delivered effectively for trainees to learn and

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retain new skills and knowledge (Baldwin and Ford, 1988; Bates and Holton III, 2004). Also, individual characteristics such as motivation to learn (LePine et al., 2004), pre-training self-efficacy (Mathieu et al., 1992), job attitudes (Noe and Schmitt, 1986), and reaction to training (e.g. trainees' engagement with the instructional methods) (Kirkpatrick, 1998) may influence the success of training.

In summary, a conceptual model of training transfer adapted from the TPB is shown in Figure 2.

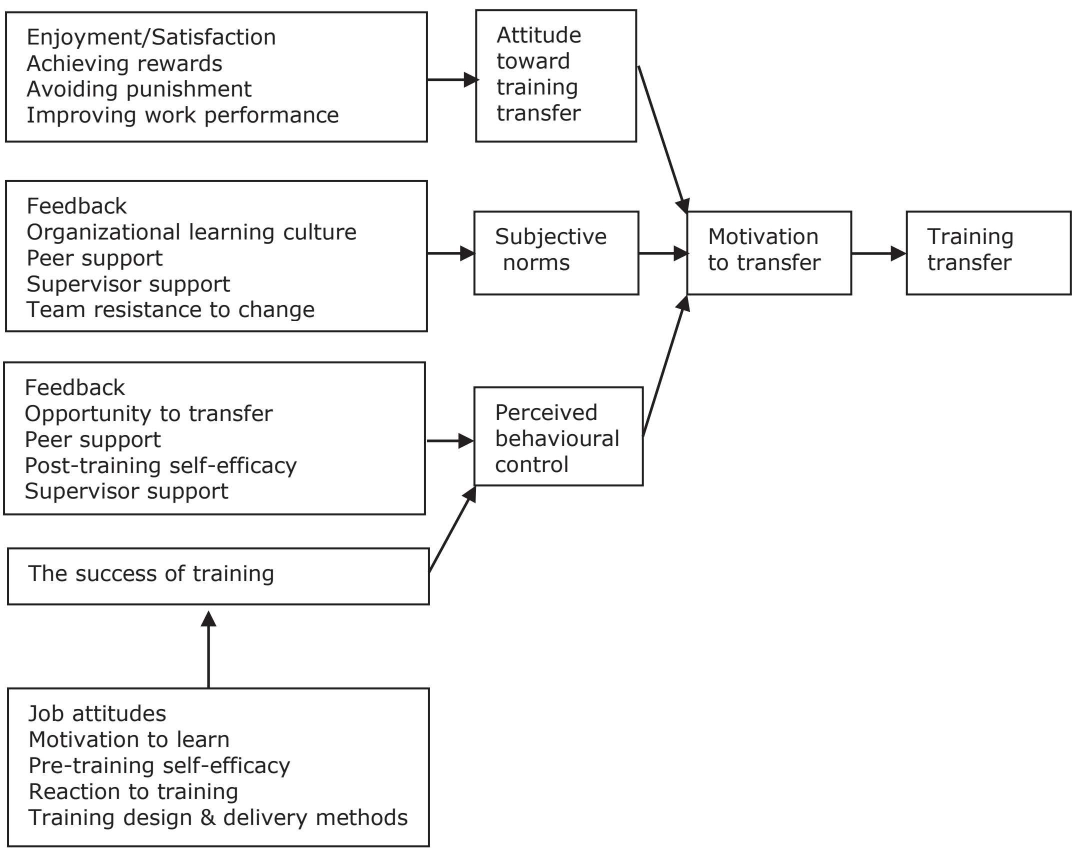

Figure 2: The conceptual model of training transfer

CONCLUSION

After seven decades, training transfer is still a challenge for industries, including the construction industry. Many models of training transfer have been introduced, but they are not supported by strong theoretical foundations. The TPB, which is a robust theory in psychology, may play a role in explaining and understanding the training transfer phenomenon. Based on this expectation, this paper proposed a conceptual model adapted from the TPB. In the following stage, an empirical study will be conducted to validate and refine this model to explain why training transfer happens, with a focus on the construction context. Also, because

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training is the prerequisite of training transfer, it is crucial to investigate how training transfer occurs in different training approaches. By doing so, we can gain a deeper understanding of training transfer, then develop appropriate strategies to facilitate employees' application of learned skills and knowledge in practice.

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APPRAISING CONSTRUCTIVE ALIGNMENT IN A CONSTRUCTION MANAGEMENT PROGRAMME

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ABSTRACT

Construction Management (CM) programmes generally build on principles in traditional science and social-science disciplines, creatively applied to the construction sector. In the last two decades, there has been significant growth in the number of universities in Australia and UK, offering construction management programmes. Despite these trend, there has been dearth of studies that investigate the alignment of the curriculum content with assessment requirements in construction management subjects.

This study appraises the issues pertaining to constructive alignment in construction management programmes delivered in the higher education sector. This work provides an ethnographic insight on the perceived benefits of Constructive Alignment in relation to academic performance, student experience, and student-satisfaction in the UK. Future work will compare outcomes in constructively-aligned courses in other academic institution. This work also suggest best practices for implementing constructive-alignment in the delivery of built environment courses.

Keywords: constructive-alignment, construction-management, ethnography, higher-education

INTRODUCTION

The origins of Construction Management programmes in universities date back to the mid-1960's (Langford and Hughes, 2009). It is however worthy of mention that newer universities seem to be on the frontiers of advancing and delivering construction management programmes. The earliest harbingers of construction management were University of Manchester Institute of Management and Technology (UMIST), now part of the University of Manchester, UK. The ARCOM Conference in 2016, paid tribute to the role of UMIST in starting out the CM discipline, in its keynote address at Manchester titled "getting back to the roots".

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Since its inception, the attractiveness of the construction management programme has soared immensely amongst new graduates of different disciplines. It is not unusual to have graduates of political science, business management, and even electrical engineering enrol in postgraduate construction management courses. Actually, many of these universities in the UK, and even Australia, introduced construction management as postgraduate degrees, and thus first-degree graduates of civil engineering, architecture, quantity surveying and building were often enticed by the prospects of a top-up degree that honed their managerial aptitude and enhanced their employability in a range of construction disciplines.

There have been many academic standards developed around the world to ensure the quality of construction management graduates. Newton (2011) reports on three threshold outcomes identified in Australian construction management programmes – judgement, self-development and communication. This generic practice skills are not exactly subject-specific, suggesting a need to establish the link between the curriculum content and the assessment requirements in construction management (CM) subjects. The CM curriculum in many academic institution especially in the more developed countries is influenced by a number of stakeholders including government, construction industry, academia, professional bodies and associations (McArdle et al., 2012).

Newton (2016) argues that professional expertise in construction management requires normative discipline knowledge and professional experience. It may however be difficult to develop the needed 'aptitude' if the assessment requirements in construction management subjects are not closely connected to the curriculum content in institutions offering construction management programmes. Despite these trend, there has been dearth of studies that investigates the alignment of the curriculum content with assessment requirements in construction management subjects. Constructive alignment, is a robust pedagogical framework to ensure that assessment in construction management subjects matches the 'taught elements' in the educational curriculum.

This paper appraises the theory of constructive alignment in the construction management discipline. This pilot study focuses mainly on the academic performance, student-satisfaction, and student-experience ratings of student cohorts enrolled in a construction management programme.

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CONSTRUCTIVE ALIGNMENT (CA)

According to Gajendran et al., (2014), constructive alignment (CA) is implicit in the design of educational courses and relevant across the spectrum of every intentional learning. Biggs (2011) explains that CA engages learners using meaningful learning activities, individual worldviews and experiences in understanding the world; to engage with new concepts and ideas. CA essentially draws upon the Personal Construct Theory, developed by Kelly (1955).

CA is essentially a bottom-up approach to the design and delivery of taught courses. There are two important schools of thought in CA. First of all, CA can be viewed as a framework for designing courses, as well as a heuristic for quality assurance in education providers (Biggs, 2011). Neither of these perspectives are disparate and disconnected, rather they complement each other.

Morris (2008) found the CA-designed courses achieve higher mean marks and strong correlation between student-confidence and examination performance. It is however unclear whether this is the case in construction management subjects. Intuitively, the benefits of CA however seem apparent. McMahon and Thakore (2006) argued that CA accomplished greater standardization leading to fairer and more reliable assessment; greater transparency; more effective evaluation, greater coherence in programme of learning and enhanced student engagement.

The Action Research – Reflect >>> Plan>>>Apply >>>> Evaluate, is the conceptual methodology that underpins Constructive Alignment. Action Research has been a well-understood and useful theory in Construction Management Research. According to Fellows and Liu (2015), Action Research involves the participation of researcher in a process in order to identify, promote and evaluate problems. In CA, this involves an intentional attention to the components of a course–assessment, teaching plans and schedules as well as teaching philosophy and practice.

CONSTRUCTION MANAGEMENT PROGRAMMES

Construction management (CM) programmes originated from different worldviews. Some higher education sector, considers the CM as an extension of the civil engineering degree, while some others, seem to view CM as more closely associated with the social-sciences. The implication of this worldview was that CM programme was delivered as an education, rather than a training (Langford and Hughes, 2009). This equally had an effect on the calibre of university teachers in CM. Many of whom mostly consisted of industry-accredited staff that had years of experience in a traditional construction role. In recent years, trends have shifted towards recruitment of staffs, with higher academic qualifications and in many instances, little or no industry experience (Forsythe and Zou, 2006). Going by the trend, it could be hypothesized that CM academics in the future seem better positioned for university appointments to have had an education rather than a training. Skinner (1984) describes education' as the residue of knowledge, that outlasts memory.

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McNamara (1997) argues that CM graduates need to be adept in both the technical and soft skills, required in the construction industry. In addition, the content of CM programme potentially has economic implications for universities. For institutions viewing CM as a purely soft-discipline (social-science) education programme, the learning medium are essentially class-based, and in some many cases, amenable to full-online delivery. However, other institutions that provide CM has a training often have hands-on components, that require students to be physically present at some point on the campus.

Many CM programmes are taken at postgraduate and undergraduate levels. In more recent years, CM has been combined with other traditional disciplines hence many universities across the world are starting to 'market' double-degree programmes such as Construction Management with Civil Engineering, Architecture, Project Management, and even Facilities Management. There is a possibility that in the future, CM courses will include energy simulation, value engineering, and business management, to retain its relevance in a highly competitive business landscape

The CM programme has also been significantly propped up by many industry-platforms. One of the most prominent construction management platforms was ARCOM, which started out in 1984. ARCOM has particular focus in promoting built environment education, and developing early-career researchers. The CIOB also has a similar role but tends to be more industry-focused unlike ARCOM. CIOB provides professional accreditations at different levels to construction professionals. The CSIRO is another supporting organisation of CM education. CSIRO is Australian national science agency, and performs similar role to the BRE in the UK. Other relevant institutions include the Construction Industry Council (CIC), Construction Industry Institute (CII), originally US-based but also replicated in Australia. Construction Industry Research and Information Association (CIRIA) is also UK-based but is committed to improvements in the construction sector. The CNBR – Co-operative Network of Building Researchers started out from Australia. The CNBR was initiated by Peter Edwards and Frederick Pretorius in an AUBEA conference in 1991. CNBR provided a platform for construction academic, researchers and practitioners to be involved in web-based communication. It is quite noteworthy that AUBEA has contributed to the dissemination of notable ideas in diverse field of disciplines. Other bodies that have inputs in the curriculum design of the CM discipline include the Royal Institution of Chartered Surveyors (RICS), Association of Project Management (APM), and Council of Heads of the Built Environment (CHOBE).

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ETHNOGRAPHY

Ethnography has been used a method of research in education settings for over three decades (Gordon et al., 2001). The scope of areas used in ethnographic initiatives include social interaction research, cultural studies, feminism, diversity, and materialist approaches. The predominant ethnographic educational research are ethnomethodology, phenomenology and symbolic interactionism (Gordon et al., 2001). Ethnomethodology simply provides a platform to understand the principles for organising human cohort; and aims to define the concept and content of knowledge. Phenomenology deals with focus on specific events and activities, while symbolic interaction seeks to focus on the social norms that informs human behaviours.

According to Shipton and Hughes (2013), ethnographic research methods, are becoming more commonplace in Construction Management (CM) research.

The ethnographic approach in the study is tailored after the phenomenology method and requires the observation of student behaviour, statements and body languages, to gain an insight into their motivations and issues. Ethnography is rooted in anthropology and requires an intense level of interaction between researcher and respondents (Fellows and Liu, 2015). Data was collected over 20 hours of observations, 5 interviews and feedback surveys. The Ethnographic studies took place over a period of three months in the UK university. There was a 2-hour weekly interaction at the UK University over an 11-week period truncated by an inter-semester break. There were only about twenty-two students participating in the interaction. The ethnographic interaction happened in the context of a class lecture and therefore secured the voluntary participation of students.

The researcher also obtained comments from the routinely conducted student-satisfaction survey to further validate the perception of students. The broad categories of satisfaction examined in this study were centered on quality of teaching, assessment and feedback, academic support, organisation and management, learning resources, personal development and overall satisfaction..

The purpose of the ethnographic study was to gain insights into the efficacy of the construction alignment method. The ethnographic procedure is however steeped in subjectivism, and interpretations by the researcher could be misconstrued. The data was collected and analysed based on the emic and etic orientations, as described by Fetterman (2010)

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DISCUSSION

The information obtained from the ethnographic interaction revealed the efficacy of constructive alignment on crucial learning outcomes of students. This work assesses the impact of constructive alignment on three student outcomes that are arguably the concern of many higher education institutions – Student Experience, Student Performance and Student Satisfaction. Although, there are many other student-outcomes, however, this three student-outcomes are central to the attraction and retention of students, by higher education sectors. This outcomes have also been recognised by many academic platforms in construction management including ARCOM, CIOB, AUBEA, and RICS.

Student Experience

Constructive Alignment has potentials to enhance the student experience (Biggs, 2011), and students enrolled in construction management programmes are no exception. While there are other issues such as employability, professional expertise, communication and digital awareness, this study simply addresses student-oriented issues such as flexibility, industry-awareness, development, and rigour. The dominant cohort in many construction-management programmes at postgraduate level tend to be international students. However, many institutions rarely incorporate some form of 'internationalisation' in the construction management curriculum (Wang et al., 2010). This often diminishes the quality of student experience. However, many students also appreciate the level of exposure, accountability and engagement of western-styled education, and this often results in an overall excellent performance.

Academic Performance

Students in the UK University investigated attained an average mark of 78%, with the least score being 48%, and the highest score being 92%. Marks attained by students have been closely correlated to student-satisfaction levels. In addition, good marks has been found to enhance the self-esteem of students (Baumeister et al., 2003). Given the spate of mental health issues in the higher educational sector (Hill, 2012), it becomes important to recognise and understand the need for sustained but deserved academic performance of students. In this study, it was found that constructive alignment, helps to bridge the nexus between the expectations of students, and the intentions of tutors. The assessment in the CM programme also serve as a medium of communicating and justifying the learning outcomes and the specific aptitude developed in individual units or courses. Biggs and Tang (2007) had previously stated that emphasis on student performance was critical to the CA approach.

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Student-Satisfaction

According to Forsythe and Zou (2006), student-satisfaction are often measured via standard survey instruments. More recently, a number of universities have adopted electronic means of administering surveys in order to reflect more genuineness, transparency and accountability. However, electronically-administered surveys are prone to low responses, and could be less-popular compared to paper-based surveys, where captive audiences may be readily inclined to provide instantaneous responses on their experiences and expectations. Regardless of the survey mechanism, Carrol (2016) reported an overall satisfaction of over 75% in Construction Management courses, a marked improvement from the situation 10 years ago. The study also found that student enrolled in constructively-aligned subjects may be inclined to higher dissatisfaction levels, compared to cohorts in non-constructively aligned subjects The possible explanation for this, is that constructive alignment may be viewed as tick-boxes to the delivery of education, and hence student satisfaction could stem from a 'mismatch' between what was promised in the courses, and what was achieved. A classic case of 'over-promising' and 'under-delivering'. In the ethnographic study, it was found that 'Constructive alignment' (CA) has the benefit of enhancing accountability between staff and student. However, CA could make students more vulnerable to dissatisfaction. For instance, students in constructively-aligned subjects often muttered that "this was not expressly requested in the assignment brief". Another common comment in this study, was that "taught content may not match the assignment". Constructive Alignment thus have the potential of placing knowledge into set boxes, and intensifies the focus of students on assessment, an observation consistent with customer-oriented learning (Boud and Falchikov, 2006). In this study, the student cohort investigated attained a student-satisfaction level of over 80% in the CM subject investigated. However, some comments were made regarding the areas of improvement in the unit.

CONCLUSION AND FUTURE TRENDS

CM programmes are popular amongst new graduates seeking for a career in the construction industry. However, there not much has been done in reconciling the student-outcomes and the design of construction management curriculum. This study appraises three key student outcomes – student experience, academic performance and student satisfaction, based on an ethnographic study in a UK university. The paper advocates for constructive alignment in better responding to student-needs, and developing a more fit-for-purpose curriculum for construction management education.

The work however suggests that CA needs to take into cognisance, the input of students in designing courses, and also involve educational stakeholders, at all levels. Student-satisfaction levels in CM programmes

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are relatively high. However, this can still be enhanced through strategic implementation of CA, taking into cognisance the needs of CM students, who are in search of flexibly, industry-oriented and relevant knowledge that holds potential to enhance their employability in a highly competitive business environment.

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IMPROVING THE STUDENT EXPERIENCE WITH LEARNING ANALYTICS IN CONSTRUCTION PROJECT MANAGEMENT COURSES

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ABSTRACT

Learning analytics is an emerging field that has been gaining momentum in higher education. Learning analytics is the analysis and reporting of learner related data. Research has examined the benefits of learning analytics in higher education but there has been limited research conducted about the impact of showing students their own learning data. The aim of this study was to provide students with their own learner data, obtain feedback about the usefulness of this information and investigate if providing learning data leads to an increase in self-efficacy and self-reflection. The sample consisted of 78 students studying construction management, project management, and property and valuation. Students were provided with weekly learner reports that included data about their behaviour in a learning management system, their level of interaction in lectures, and their performance on assessments. A suggested target was provided toward an individualised behaviour goal, as well as comparison with both the contemporary class average and previous class averages. Students completed measures of self-efficacy and self-reflection pre and post intervention and feedback about the reports was obtained through surveys and a focus group. Results showed no significant change in self-efficacy and self-reflection, however, students reported finding the learning analytics reports helpful, believed it helped them reflect on their own learning and wanted to see more analytics in other subjects. Results support the use of learning analytics in the classroom and suggest that they may enhance the student experience.

Keywords: Learning Analytics, Higher Education, Construction Project Management

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INTRODUCTION

Learning analytics has been viewed as having the potential to transform learning and teaching in higher education. Learning analytics is the analysis and representation of data about learners to improve learning (Clow, 2013). The field of learning analytics is related to pre-existing domains, such as educational data mining and web analytics (Prinsloo, Slade & Galpin, 2012).

Higher education institutions have used learning analytics data to identify and appropriately support students, whether they are at risk, underprepared or high performing (Prinsloo, Slade & Galpin, 2012). Recent technological advances have seen the advancement of learning analytics, such as predictive analytics (Waller & Fawcett, 2013) and the development of apps to monitor student behaviour and provide data regarding well-being, mood and academic performance (Wang et al., 2014).

There are numerous pedagogical implications associated with learning analytics. Learning analytics provide staff with a pedagogical device that can be used in a neutral, formative way to help students become more aware of their own learning and to help understand why they may be facing particular challenges. The potential exists to use learning analytics in the classroom to help students engage in their own learning.

Information about student performance or learning behaviour can be collected from a range of different sources. Data has traditionally included student enrolment data, academic records, student surveys, and data from online discussion boards. Data about student behaviour can also be obtained from students' interactions with university learning systems (Aljohani & Davis, 2012).

Learning management systems (LMS), such as Blackboard and Moodle, attempt to replicate traditional classroom and institutional processes with the inclusion of formal assessments, courses and classes (Rahman and Dron, 2012). The Substitution Augmentation Modification Redefinition model, developed by Puentedura (2011) describes levels of technology integration and how it might impact learning and teaching. The model shows how technologies, such as LMS, may transform and enhance previous educational methods if the technologies are appropriated, implemented and designed. One of the benefits of an LMS is that it can provide built in learning analytics that can be used to monitor student behaviour and provide feedback to educators. Data about students can be gathered objectively and with relative ease. Research has suggested that learning analytics from an LMS may help reduce attrition, show student progress and identify students in need (Arnold & Pistilli, 2012; Picciano, 2012; Siemens & Gasevic, 2011). In addition, some studies suggest that student behaviour in an LMS predict academic performance. In their study

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of nine undergraduate courses in Australia, Gasevic et al. (2014) found that number of logins, resources used and operations performed in discussion forums were significant predictors of academic performance. Despite the positive implications of these findings, there are likely to be moderating variables that impact LMS use and academic performance and the authors note that it is difficult to translate these findings into actionable recommendations for students (Gasevic et al., 2014). Furthermore, other research has found that LMS use does not predict academic success (Broadbent, 2016). It would be beneficial to further examine how LMS use can be used to assist students.

Despite the advances in technology and relative flexibility of most LMS, one of the major limitations of learning management systems is that they do not lend themselves to learner-centric approaches (Rachman & Dron, 2012). Students are generally not given the opportunity to adapt the LMS to cater to their own learning. Further, the learning analytics offered in the LMS tend to be available to educators but not students. The inability to easily retrieve and adapt data for students in the LMS presents a challenge for the use of learning analytics. Authors have also noted concerns associated with learning analytics, including the potential to create a culture of student surveillance rather than empowerment (Slade & Prinsloo , 2013).

Students' beliefs about their academic capabilities have long been thought to play an important role in their motivation and ability to achieve (Zinmmerman, 1999). In particular, self-reflection and self-efficacy have been found to be important predictors of academic performance. Self-reflection refers to an individual's ability to analyse their own behaviours with outcomes i.e. what actions lead to reactions? Where positive reactions occur, how can we understand and increase the action that led to them? Self-efficacy is an individual's belief that they are likely to succeed in a task (Stajkovic & Luthans, 1979). Students who have higher self-efficacy are more likely to be confident learners and are more likely to participate, engage and persist with their academic studies (Pajares, 2007). Self-efficacy is a strong predictor of academic achievement and success (Broadbent, 2016; Chemers, Hu & Garcia, 2001). It is therefore important to understand ways of improving a student's self-efficacy, but integral to doing this is to have them learn about, and reflect on, their own learning behaviours.

Learning analytics have tended to be used and viewed from the educator's perspective. However, there are substantial benefits to directly sharing learning analytics with students (Prinsloo, Slade & Galpin, 2012). Individual pieces of data may not be inherently useful, but when collected and analysed in cohorts, learning analytics has the power to inform students about how they are progressing, how their learning behaviours compare with other students, as well as information such as learning characteristics of students who are performing at higher levels. When

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given to students and used as a reflective device, learning analytics may also inform students about how many hours they are spending on learning tasks and how they engage with different types of materials, thus, showing how to maximise learning. Learning analytics can teach students about their own learning behaviours, giving them more insight and agency in their learning.

The purpose of this study was to provide students with personalised data from a range of contexts, including behaviour in an LMS, assessment performance, and interaction in lectures. As well as individual data, students were also provided with class comparison data. This project aimed to use these learning analytics to promote learner self-reflection and self-efficacy. In addition the study sought feedback from students on the perceived value of this data.

METHODOLOGY

Students in a first-year undergraduate construction management course at a large Australian university were invited to participate in the research. Of the 151 students enrolled in the course, 78 students (23 female, 53 male and 2 other) agreed to participate in the study. Participants ranged in age from 18 to 25.

Learner data reports were provided by email at the end of each week throughout the 12-week semester. The learner data was collected from three different sources: LMS, lecture participation and weekly assessment performance (described in detail below). Student self-efficacy and self-reflection were measured at the beginning and end of the semester.

An action research approach was used (Kemmis & McTaggart, 1988). A cyclical (plan, act, observe, reflect) and participative model was adopted, with students actively engaged to help construct and improve the learner reports throughout the semester. `

Ethics approval to conduct the study was obtained by the Human Research Ethics Committee (HREC).

LMS user of learner data

The LMS was used in this course to provide learning resources, including readings and lecture recordings as well as assessment tasks, rubrics and guides. Students submit their assessment tasks via the LMS.

The research team extracted learner data available on the LMS including total number of times students have accessed different areas in the LMS and the breakdown of total hours per week. This data was presented to students visually as individualised data. This information provides data about student behaviour but it does not indicate the level of engagement

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with the material. The class average was also provided for comparison. A sample LMS report is shown in figure 1.

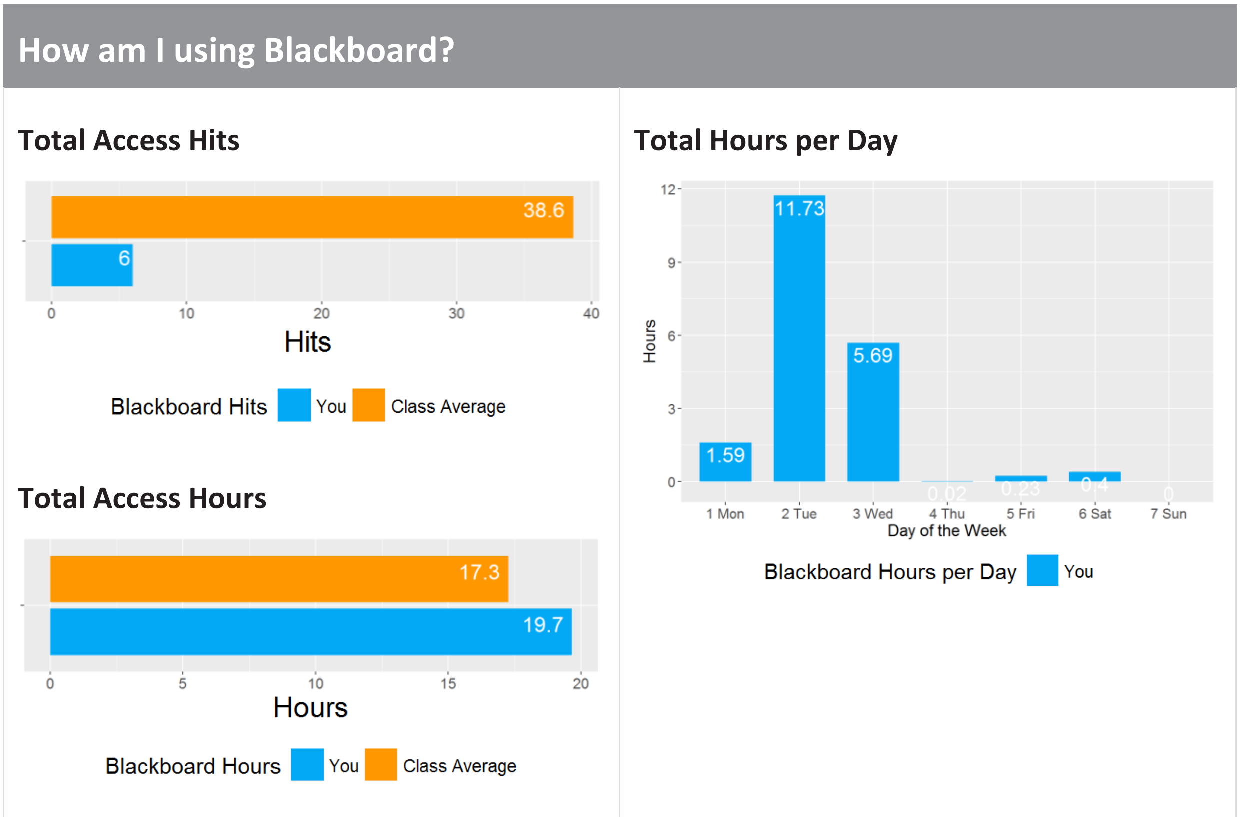

Figure 1 Sample LMS user data report

Lecture participation data

The second source of learner data was lecture participation. In order to create an interactive learning environment, each lecture was broken down to smaller topics or concepts. Each concept concluded with a class activity. Students reported the result of their activity using a real time polling system. Turningpoint was used to create the real-time polling and Responseware was used for collecting the student responses and collated responses were shared in the lecture. Individual student responses were collected, collated, and reported back to students with class average comparisons. Figure 2 shows a sample of the lecture participation report.

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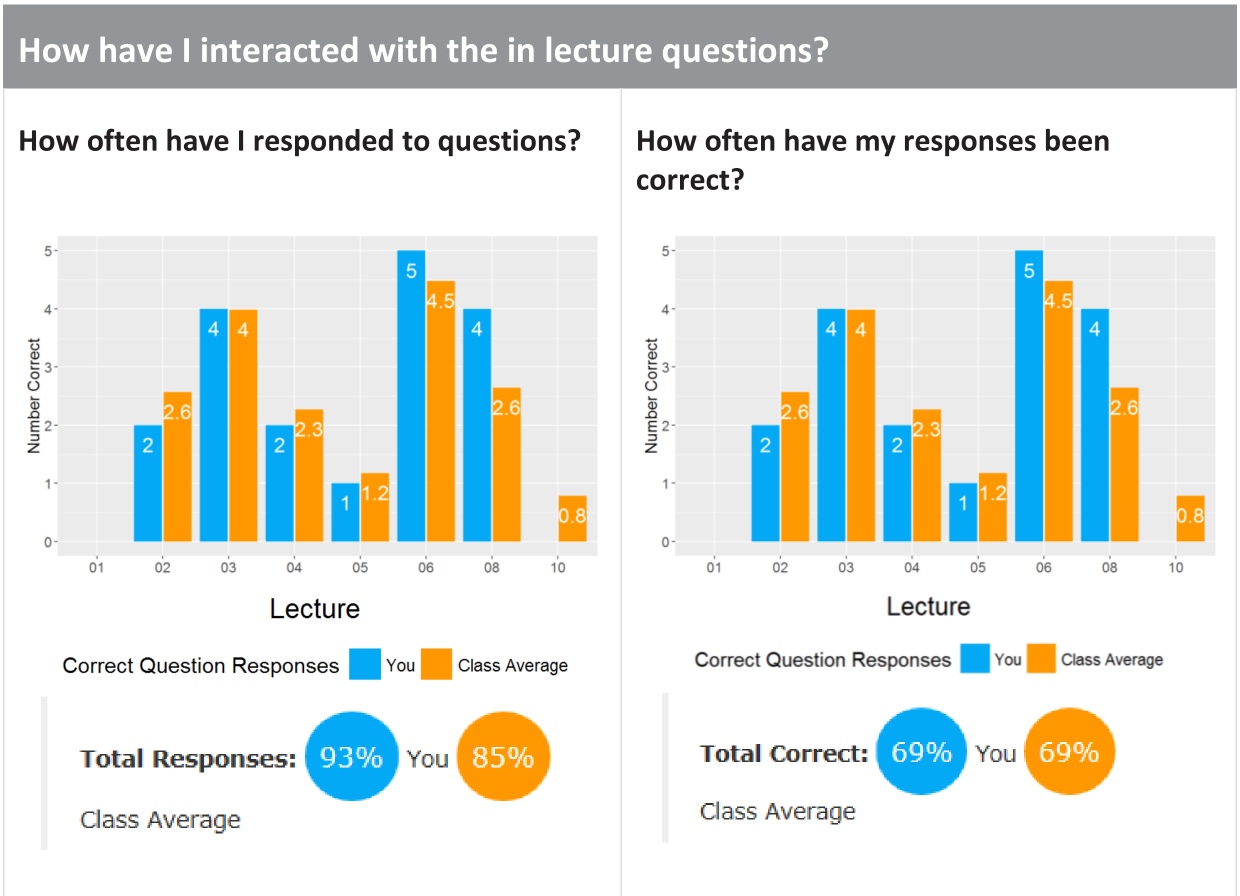

Figure 2 Sample lecture participation report

Weekly assessment performance

The third source of data was individual weekly assessments results. One of the assessments in this course was a continuous formative task. Students were required to apply their learning on the weekly tasks and submit their work every week. These tasks were marked and the feedback and marks were provided to the students by the end of the week. Figure 3 shows a sample of the weekly student performance report.

The data provided to the students included four components:

I. Student's weekly mark: this was produced based on the lecturer's assigned mark for the weekly assessment task.

II. Class weekly average mark

III. The weekly average mark of the previous cohort: this included the average mark for the weekly assessment task from the class from the previous year.

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IV. Personal target: students were asked at the beginning of the semester to set a target grade for the course as a whole. Students were reminded of this target in their weekly reports.

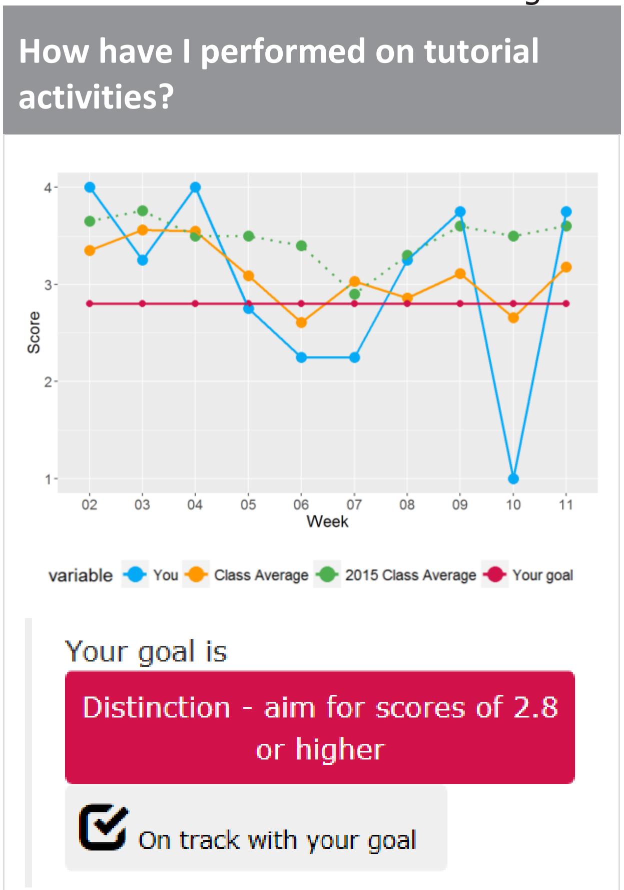

Figure 3 Sample weekly assessment report

Self-efficacy and self-reflection

Students completed the Generalised Self Efficacy Scale (Schwarzer & Jerusalem, 1995) and Self-Reflection and Insight Scale (Grant et al, 2002) online at the beginning and end of the semester. Both measures are appropriate to use in an academic context. The *Generalised Self-Efficacy Scale* consists of 10 items designed to assess optimistic self-beliefs with a variety of difficult demands in life. Research has found that the scale is psychometrically sound (Schwarzer & Jerusalem, 1995).

The *Self-Reflection and Insight Scale* was designed to measure private self-consciousness, self-reflection and insight. The scale has 20 items and responses are provided on a six-point Likert scale (1= strongly disagree, 6= strongly agree). The scale has been found to correlate positively with other self-reflection scales and test-retest reliability has been found to be .78 (Grant, Franklin and Langford, 2002).

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Student feedback on and use of the learner reports

Throughout the semester, students were invited to provide feedback to the research team. At the end of the teaching period students were also invited to complete a survey evaluating the learner reports. Students were invited at the end of the semester to attend focus groups to share their experience in an in-depth conversation with a member of the research team.

During the teaching period, the research team monitored learner report emails to determine if they had been opened. Although this is not a measure of engagement, it provided the team with information about how consistently students were accessing the reports.

RESULTS

Results of the end of semester survey showed that students valued the learner reports and these reports were perceived to have a positive impact on their learning. In total, 78% of students rated the learner data reports as helpful and the same number rated the reports as useful in reflecting on their own learning. The majority of students (80%) reported that they would like to see similar learner data reports in their other classes. One suggestion by the students was that they would like to see a learner report that incorporated data from all of their courses, providing a holistic picture of their academic progress.

Most of the students found the learner reports helpful. 44% of students rated the learner data reports that they received as 'very helpful, 33% of students rated the data reports as 'somewhat helpful,' 11.% of students rated the helpfulness of the reports as 'neutral' and 11% of students rated them as 'somewhat unhelpful.' These findings suggest that, overall students found the reports helpful.

Of the information they received, students reported that LMS hits were the least useful because they were not as informative as the other pieces of data.

A small percentage of students (11%) did not find the learner reports helpful. Further interrogation revealed that these students were not progressing well in the course and were either failing or just passing. Follow up conversations with these students indicated that the learner report was not perceived to offer any new information – these students already knew they were not doing well. In the focus group students suggested that they would have liked suggestions for how to improve and links to resources and support. They also recommended that the reports form the basis for a follow up conversation with teaching staff focused on suggestions for improvements in their studies.

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The majority of students (78%) opened their emails about learner data and most of the students (65%) reported that they were opening their reports on a weekly basis. This suggests there was a considerable interest in students seeing their learner's data. The anecdotal conversations with the students throughout the research implementation phase also confirmed this interest.

While students appeared to appreciate the learner data and perceived it as useful for their learning, comparison of scores on the Generalised Self Efficacy Scale and Self-Reflection and Insight Scale revealed only small improvements over time. Neither was significant.

Students reported that they felt that self-reflection would have increased if the reports had been discussed in class. Students felt that discussion in class would have provided a deeper understanding of the reports and a greater chance to interpret what they meant.

Students reported that they liked being able to see how they compared to other students as it gave a better sense of their performance and they could track when other students found certain assessments difficult. Particularly, this comparison is helpful for the first year and exchange students who have not yet created their networks. The reports provide them with a benchmark to that they can compare themselves.

CONCLUSIONS

Learning analytics has been viewed as having the potential to change learning and teaching in higher education. Higher education institutions have used learning analytics primarily to identify and address the challenges the students face. These applications of learning analytics are predominantly developed from an educator's perspective. However, there are potential benefits to directly sharing analytics with students.

This research investigated the use of learning analytics to enhance the student experience. A large cohort of students in a construction project management course were chosen for the study. The learner's data were analysed and fed back to students. Student feedback was sought throughout the project implementation and at the end of the semester through student surveys. A focus group was held to receive in depth feedback from students.

Overall, the results indicated that students valued the learner reports they received and felt that it had a positive impact on their learning. This is an important finding as it demonstrates that students are interested in their own learning behaviour and that learning analytics may be useful for students as well as staff. Based on the current findings learning analytics may improve the student experience.

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Most students reported that the learner reports helped them reflect on their own learning and the majority students reported that they would like to see similar learner data reports in their other classes. These findings confirm the usefulness of such reports and demonstrate that, when used appropriately, learning analytics has the potential to help students engage in their own learning.

The results did not show any significant changes in self-efficacy or self-reflection. The information provided to students did not increase their belief in their ability to achieve. There are a number of potential reasons for this. The information provided to the students did not provide any tips, suggestions or ideas about what to do with the information they received. It may have been beneficial to have given students direction about what to do to help change their behaviour. For example, students with low scores on assessments could have been provided with links to services or tips on how to help improve their learning or scores. It may have also been that students did not process the information in the learner reports. The only data we have available is about how often the emails were accessed. By itself, this information is limited and tells us little about how students engaged with the material. It may have been beneficial to have discussed the learner reports in class to help strengthen student understanding and engagement with the reports.

The research has demonstrated that learning analytics can enhance the learning experience. Students suggested a better analytics report in which a single report integrates all their analytics from all courses.

To our knowledge, this is the first study that has actively shown students their own learner data. Providing learner's data to the learner is a new area that creates new dynamics in classrooms. Participants of this study suggested follow up conversations with the instructor after they received their reports. This opens new areas of work for student experience enhancement and introduces new dynamics to the classrooms that require further investigation.

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OVERVIEW AND ANALYSIS OF DIGITAL TECHNOLOGIES FOR CONSTRUCTION SAFETY MANAGEMENT

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ABSTRACT

Digital technologies are increasingly used to support safety management in the construction industry. Previous efforts were made to identify digital technologies for safety in the construction industry. However, limited research has been done to conceptualize the roles played by digital technologies in safety management and accident prevention. This paper surveys state-of-the-art research between 2000 and 2016 in order to categorize digital technologies for construction safety, identify research trend, and analyse their roles in accident prevention. The research employs a systematic process to review the existing literature on digital technologies in the area of construction safety. Five academic databases, Science Direct, Taylor & Francis, the ASCE Library, Engineering village, and Web of Science, were selected for the survey due to the comprehensive coverage of relevant academic papers. The survey identified 15 digital technologies: real-time location system and proximity warning, building information modelling, augmented reality, virtual reality, game technology, e-safety-management-system, case-based reasoning, rule-based reasoning, motion sensor, action/object recognition, laser scanning, physiological status monitoring, virtual prototyping, geographical information system, and ubiquitous sensor network. Three emerging safety functions claimed and/or promoted by DTs were discussed: enhanced safety planning, real-time hazard management, and safety knowledge engineering. It is concluded that DTs have great potential to improve safety performance by engineering resilience and adaptiveness at the individual level, while how DTs embody safety values and how safety values in turn influence the adoption of DTs remain an open question.

Keywords: accident prevention, construction safety, digital technology

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INTRODUCTION

We are living in a digital age. Digital technologies (DTs) have changed the way people live, work, communicate, and learn. The past two decades have seen a growing interest among researchers in applying DTs to safety management in the construction industry. A powerful motivator is that construction safety performance has reached a plateau and that DTs have promising potential to eliminate the bottleneck. It is widely believed that DTs can improve limited human conditions and thus revolutionize traditional safety management process which is largely manual, time-consuming and error-prone.

Previous efforts were made to systematically review the technology applications for construction safety. For example, Zhou et al. (2012) reviewed two different strands of research, digital tools for managing safety through construction and design, in order to understand the relationship between digital technologies and safety performance. In addition, Zhou et al. (2013) provided a general overview of technology applications for construction safety from 1986 to 2012. Emphasis has been placed on identifying type of technology, project phase, and project type. This paper extends recent literature review on DT applications to construction safety by placing emphasis on theorizing the role of DT in accident prevention and safety management. In specific, the objectives of this paper are to (1) identify the development and applications of digital technologies to construction safety, (2) analyse the functions of digital technologies and their roles in accident prevention and safety management.

METHODS

This paper uses a method of literature review adopted by Zhou et al.(2013). The method consists of three main steps: (1) literature search, (2) literature selection, and (3) literature coding.

Five academic databases, Science Direct, Taylor & Francis, the ASCE Library, Engineering village, and Web of Science, were selected for the survey due to the comprehensive coverage of relevant peer-refereed academic papers. 656 papers were identified by the preliminary search. Search terms and results are presented in Table 1.

Table 1 Preliminary search terms and results

Datebase	Search terms	Results
ASCE Library	"BIM" OR "rule-based reasoning" OR "case-based reasoning" OR "expert systems" OR "wearable technology" OR "sensing" OR "warning" OR "virtual reality" OR "augmented reality" OR "wireless technology" OR "geographic positioning system" OR "GPS" AND “Safety”	291
Engineering village	(((("BIM" OR "rule-based reasoning" OR "case-based reasoning" OR "expert systems" OR "wearable technology" OR "sensing" OR "warning" OR "virtual reality" OR "augmented	52

	reality" OR "wireless technology" OR "geographic positioning system" OR "GPS") WN TI) AND ((construction) WN TI)) AND ((safety) WN TI))	
Science Direct	TITLE-ABSTR-KEY(BIM OR building information modelling OR rule-based reasoning OR case-based reasoning OR expert systems OR wearable technology OR sensing and warning OR virtual reality OR augmented reality OR wireless technology OR geographic positioning system OR GPS) and (Construction AND safety).	93
Taylor & Francis	[[All: "construction safety"] AND [All: "bim"]] OR [All: "rule based reasoning"] OR [All: "case-based reasoning"] OR [All: "expert systems"] OR [All: "wearable technology"] OR [All: "sensing"] OR [All: "warning"] OR [All: "virtual reality"] OR [All: "augmented reality"] OR [All: "wireless technology"] OR [All: "geographic positioning system"] OR [All: "gps"] AND [Publication Date: (01/01/2000 TO 12/31/2016)]	185
Web of Science	TITLE: (BIM OR building information modelling OR rule-based reasoning OR case-based reasoning OR expert systems OR wearable technology OR sensing and warning OR virtual reality OR augmented reality OR wireless technology) AND TITLE: (construction) AND TITLE: (safety OR accident OR hazard)	35

In the literature selection phase, all book reviews, editorials, and conference papers were excluded and only journal papers were selected. This resulted in 111 papers for further analysis. All remaining papers were coded according to (1) title, (2) publication year, (3) digital technology, (4) journal title, and (5) country or region (all authors were counted).

RESULTS

Results are presented as follows in terms of journal title, country or region, publication year, type of DT, and annual distribution of DT.
As Table 2 shows, *Automation in Construction (AIC)* and *Journal of Computing in Civil Engineering (JCCE)* cover around 59% of the identified journal articles, with 45 and 20 papers, respectively, published between 2000 and 2016. Apart from *Safety Science (SS) and Journal of Construction Engineering and Management (JCEM)* which published 12 and 12 papers, respectively, other journals contain proportionally much less coverage.

Table 2 Journal title and number of reviewed papers

Journal title	Number of papers
Automation in Construction	45
Journal of Computing in Civil Engineering	20
Safety Science	12
Journal of Construction Engineering and Management	12
Advanced Engineering Informatics	7

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Construction Management and Economics	6
KSCE Journal of Civil Engineering	2
Journal of Safety Research	1
Expert Systems with Applications	1
Journal of Professional Issues in Engineering Education and Practice	1
Applied Mechanics and Materials	1
Safety and Health at Work	1
International Journal of Project Management	1
Accident Analysis and Prevention	1

As shown in Fig. 1, the reviewed 111 papers are from 20 countries/regions. Among these, authors from USA and China participated in around 45% of all reviewed papers.

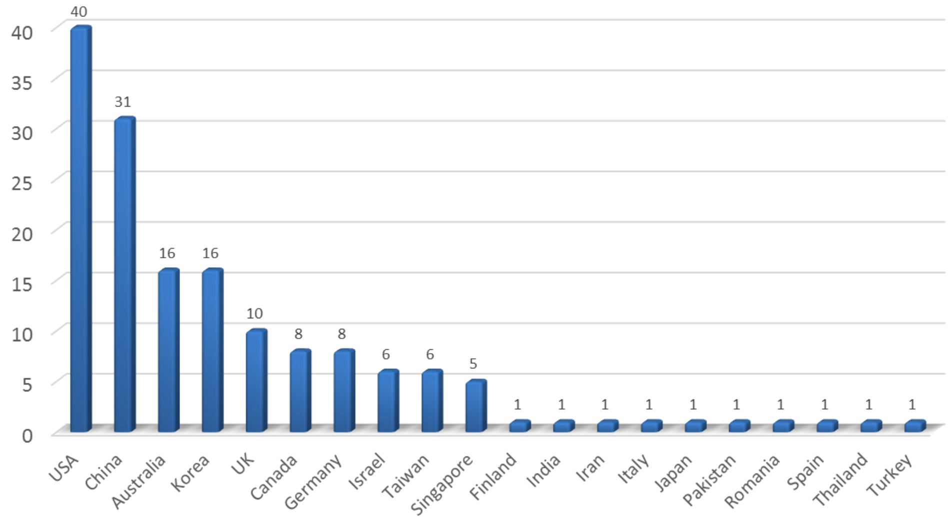

Figure 1 Geographical distribution of publications

There is an increasing number of papers between 2002 and 2016, as indicated in Fig. 2.

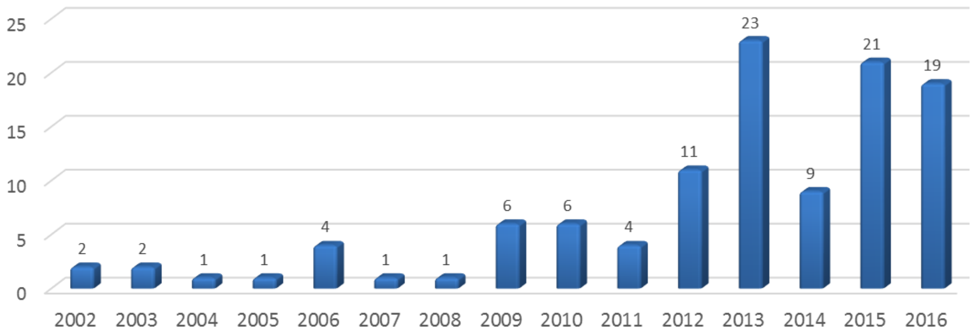

Figure 2 Annual distribution of publications from 2002 to 2016

15 DTs were identified from the literature review, including, real-time location system and proximity warning (RTLS-PW), building information modelling (BIM), augmented reality (AR), virtual reality (VR), game technology(GT), e-safety-management-system (ESMS), case-based reasoning (CBR), rule-based reasoning (RBR), motion sensor (MS),

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action/object recognition (AR/OR), laser scanning (LS), physiological status monitoring (PSM), virtual prototyping (VP), geographical information system (GIS), and ubiquitous sensor network (USN).

RTLS-PW covers a wide range of technologies, such as Radio frequency identification (RFID), Global positioning system (GPS), Ultra-wideband (UWB), Vision analysis, Wireless local area network (WLAN), Ultrasound, and Infrared (IR), with different features, advantages, and limitations (Li et al. 2016; Wang and Razavi 2015). The main purpose of these technologies is to track workers, materials, and equipment and provide real-time warnings when workers approach to hazardous areas (Luo et al. 2016). As suggested in Table 3, 40 reviewed papers apply the RTLS-PW and there has been an increasing trend in recent years. As BIM gains it popularity across the architecture, engineering and construction (AEC) industry, there has been an increasing number of papers using BIM for construction safety, with 30 papers between 2002 and 2016. AR is "an environment where data generated by a computer is inserted into the user's view of a real world scene" (Wang et al. 2013), while VR replaces the real world with a simulated one. These two exciting technologies have often been integrated with BIM, or used alone, for safety education and training (Pedro et al. 2015; Sacks et al. 2013), hazard identification (Perlman et al. 2014), and design for safety (Hadikusumo and Rowlinson 2002). Game technology has also been applied with attempt to enhance safety training (Guo et al. 2012).

Table 3 Annual distribution of DTs

DT	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Total
RTLS-PW	0	1	0	1	1	0	1	1	3	2	3	8	2	7	10	40
BIM	0	0	0	0	0	0	0	2	1	2	0	7	2	9	7	30
VR	2	1	0	0	0	0	0	1	0	0	1	3	1	2	1	11
AR	0	0	0	0	0	0	1	0	0	0	1	5	1	2	0	10
RBR	0	0	0	0	0	1	0	1	0	0	1	2	0	2	2	9
ESMS	0	0	0	0	1	1	0	0	0	0	0	2	1	1	0	6
CBR	0	0	0	0	0	0	0	1	1	0	0	1	0	1	0	4
GIS	0	0	0	0	1	0	0	0	0	1	0	1	0	0	1	4
GT	0	0	0	0	0	0	0	0	0	0	2	1	0	0	0	3
AR/OR	0	0	0	0	0	0	0	0	0	0	2	0	0	1	0	3
MS	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	3
VP	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	2
LS	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	2
PSM	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
USN	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1

DISCUSSION

This section discusses key functions provided by the DTs. Due to the word limit, only three emerging functions and important research areas which are facilitated by DTs are discussed: enhanced safety planning, real-time hazard management, and safety knowledge engineering.

Enhanced safety planning

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Safety planning is a core element of safety management system. Traditional safety planning is mainly concerned with identifying and managing hazards in the construction phase. The process has been time-consuming and error-prone due to the dynamic nature of construction site (Melzner et al. 2013). Another major limitation is that it is usually carried out only during the construction and it is often ignored in design (Toh et al. 2016). DTs, such as BIM, VR, and AR, can provide a platform which allows safety planning to be performed during the design stage. Safety-related design deficiencies, inappropriate work schedule, and hazardous materials can be "designed out" based on the communication among architects, engineers, and contractors. Such communication can be enhanced by visualization and simulation. Another major benefit of visualization and simulation is that they can identify and minimize the discrepancy between work as planned and work as done. In order to save time and reduce errors, automatic hazard checking rules have been designed and implemented into BIM (Zhang et al. 2015; Zhang et al. 2013). This has promising potential to ease the tension between production and safety.

Real-time hazard management

In recent years, especially after 2010, increasing efforts have been made to apply real-time locating and proximity warning technologies to construction safety (Carbonari et al. 2011; Cheng et al. 2012; Cheng and Teizer 2013; Chi and Caldas 2011; Ding et al. 2013; Golovina et al. 2016; Li et al. 2015; Luo et al. 2016; Teizer et al. 2010; Yi et al. 2016). An exciting benefit of the technologies is that they can track the location of both workers, materials, and equipment and provide proactive warnings in real-time if workers are in dangerous zones.

This function is significant because of the fact that construction is highly dynamic in nature and that hazards emerge due to the dynamics. This poses a huge threat to workers who have to manage the dynamics constantly. Traditionally, workers are notified about involved hazards before they perform a task. They have to rely on their own experience and skills to manage both identified and unidentified hazards by utilizing their safety knowledge and adjusting their behaviour. However, such an ability is highly subject to human and contextual factors, such as safety awareness, safety motivation, work pressure, and peer pressure. This means that workers' situational awareness is unstable in terms of where they are and whether anything/anyone around them is a hazard to their safety. Accidents are likely to occur when workers are exposed in imminent and unidentified hazards, and, at the same time, their situational awareness is at a low point.

From this perspective, the technologies have potential to revolutionize traditional hazard identification activities. Real-time data and proactive warning enable workers to identify emerged hazards and make informative and safe decisions. A certain level of situational awareness can be automatically created and maintained. A loop safety monitoring and controlling can be bridged so that hazards can be either eliminated or

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isolated. Thanks to the technologies, situational awareness can even be developed in machines and equipment (e.g., trucks and cranes) (Cheng and Teizer 2012; Teizer et al. 2010). These machines and equipment are able to sense their surroundings and make safe and “intelligent” decisions. From this perspective, the technologies are able to enhance human conditions and capabilities and thus reduce human error on construction sites.

Safety knowledge engineering

Another important advancement promoted by, and in turn facilitates, DTs is ontology. Over the past five years, a number of safety-related ontologies were developed in the construction industry to formalize different domain knoweldge such as construction safety in general (Zhang et al. 2015) and active fall protection system design in specific (Guo and Goh 2017). As a foundation of knowledge engineering, these ontologies represent pioneering efforts to engineer safety knowledge and apply safety science to the construction industry. Fox (2011) defined knowledge engineering as “the engineering discipline that involves integrating knowledge into computer systems in order to solve complex problems normally requiring a high level of human expertise”. Safety knowledge engineering is a significant research area because a proportion of safety-oriented DTs would depend heavily on formalized knowledge and knowledge engineering. If formalized safety knowledge is dificient, these DTs would add little value.

Safety-related ontologies formalize empirical experiecne, standards, regulations, and best-practices and then facilitate the development of production rules (e.g., JESS rules and SWRL rules). These rules enable automated reasoning and problem solving. Thus, implementing relevant rules in DT platforms like BIM and Protégé allows one to undetake automatic safety management practices such as Job Hazard Analysis (JHA) (Wang and Boukamp 2011; Zhang et al. 2015) and safety checking (Lu et al. 2015; Zhang et al. 2013). These developments can potentially help people and company that have inadequate safety management capability.

CONCLUSIONS

This paper aims to (1) identify the development and applications of digital technologies to construction safety, (2) analyse the functions of digital technologies and their roles in accident prevention and safety management. In total, 15 DTs were identified by the survey, including real-time location system and proximity warning, building information modelling, augmented reality, virtual reality, game technology, e-safety-management-system, case-based reasoning, rule-based reasoning, motion sensor, action/object recognition, laser scanning, physiological status monitoring, virtual prototyping, geographical information system, and ubiquitous sensor network.

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The survey reveals that a vast majority of papers focus on system design and development, field experiment, and test. Little research has been done to investigate technology adoption and implementation across construction firms and projects. As such, there is lack of solid evidence that DTs have actually improved safety performance.

Nevertheless, it is concluded that DTs have demonstrated great potential to improve safety performance by enhancing safety planning, allowing real-time hazard management, and promoting safety knowledge engineering. It is clear that if the DTs are adopted and implemented, they can enhance *adaptability* at the individual level. The attribute is an important asset to site safety, given the fact that workers have to manage both identified and unidentified hazards in a highly dynamic environment. This means they have to manage discrepancies between work-as-imagined and work-as-done. This has been challenging due to limited human conditions and a low level of safety knowledge. DTs are useful as they, if adopted, can enhance traditional safety training, and, more importantly, create and maintain a passive but real-time situational awareness so that workers keep "connecting" with their surroundings. From a Resilience Engineering perspective, the *adaptability* at the individual level constitutes an essential component of *resilience* of the system (a construction company or a project) as a whole. The *adaptability, resilience* as well, improves the system's ability to deal with pressures and changes (e.g., work pressure, peer pressure, and temporary workers).

However, over-relying on DTs may be dangerous. Given lack of understanding how DTs affect worker's safety motivation and awareness, it may be an oversimplified view that DTs will be able to deliver all their promises once they are implemented in real construction projects. In addition, it is possible that there could be a collision between DTs and safety values. How DTs embody safety values and how safety values in turn influence the adoption of DTs remain an open question. Future research efforts should be made to understand DTs in a wide organizational context and theorize the roles played by DTs in a valid safety model.

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