

LEAN AWARENESS IN AUSTRALIAN CONSTRUCTION: INVESTGATING THE EXTENT OF LEAN ADOPTION ACROSS AUSTRALIAN CONSTRUCTION SECTORS

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ABSTRACT

Lean construction, its principles, tools and strategies have been widely implemented around the world, including the USA, UK, Europe and Asia. The extent and adoption of lean strategies, principles and tools within the Australian construction industry is not widely known, despite the presence of implementation and industry awareness about lean benefits. The purpose and aim of this paper is to quantitatively explore the presence, extent and awareness of lean construction principles within the Australian construction industry, as a point of reference for further study into adoption and implementation rates. A quantitative methodological approach of a questionnaire has been utilised to investigate a small population size of 1,898 of Australian companies. The focus of thee study includes residential-building, non-residential building (commercial and industrial) and other forms of building. The study also views awareness levels from public and private construction sectors. Of the population size a response rate of 42% was achieved. Of this rate 43% were residential, 29% were commercial, 19% were industrial and 9% were identified as other. The results of the questionnaire highlight that despite the lack of awareness of lean terminology, the majority of Australian construction organisations within the construction industry sector have and are utilising some lean strategies, tools or principles within their organisations.

KEY WORDS

Australian construction industry, lean construction, awareness, survey

INTRODUCTION

Increasing and improving overall construction productivity and performance has been identified as a major issue influencing international construction (Woudhuysen & Abley, 2004). From an Australian construction industry perspective the government has commissioned a number of reports as a means of investigating issues of

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productivity and performance, including *Reengineering the Construction Delivery Process*, Cole's 2002 Royal Commission, *Building for Growth and Reform of Building Regulation*. Other Australian construction sector groups have also commissioned productivity review reports including *Australian Construction Productivity: International Comparisons*. The purpose of such commissioned reports is to identify the key industry problems impacting industry standards while creating industry wide reform. Cole's 2002 Royal Commission report highlighted a potential link between the processes of construction and manufacturing, highlighting the potential awareness of lean thinking in formulating strategic reform within Australian construction.

It has been 9 years since the publication of Cole's Royal Commission report in 2002. Since this report there has been an increased awareness within industry of the benefits of lean thinking leading to lean implementation. Investigations of lean have focused on specific elements of the lean process and lean application such as information technology (Stewart et al, 2004), cultural quality (Saha & Hardie, 2005), cultural understanding (Zuo & Zillante, 2005) and head contractor roles (Perera et al, 2011). The purpose of this paper is to investigate and identify the current application, awareness and understanding of lean principles and tools within the Australian construction industry, with the intent of establishing a point of reference for further lean Australian studies. As such the paper focuses on general lean theorisation and principle development rather than applications of lean within Australian construction. Identification of lean principles will now be discussed.

LEAN PRINCIPLES & AWARENESS

Mohan & Iver (2005) reported on the effectiveness of lean principles in construction through the application and investigation of 41 lean principles, identifying 29 lean orientated benefits across 16 organisations in the USA. This study was specifically focused the application of lean principles and published reports of company experience, although limited the study has provided a basis in which to explore lean awareness and understanding on an industry scale.

Primary principle lean construction contexts originally emerged within theory particularly through the identification and discussion of lean awareness and lean implementation within industry. Principles include:

1. Reduce waste within the value stream (Koskela, 1992, 1993; Ballard & Howell, 1997; Howell & Ballard, 1998; Howell, 1999);
2. Synchronise, align and provide transparency as part of the planning process (Howell & Ballard, 1998; Ballard & Howell, 1999); and
3. Integrate TFV production theory as part of the lean implementation process (Koskela, 1992).

The development of secondary contexts for lean construction are linked to the sub-themes of each major theory grouping, the purpose of the secondary contexts is to broaden the perspectives of lean and provide more central and topical issues associated with theorisation. Secondary contexts themes include:

- **Production System Design:** Improvements through the adoption of Lean Last Planner (Ballard & Howell, 1999):
 - Structuring of workflows and workflow ability;

- Understanding, managing and controlling push and pull flows within the process (Sacks & Harel, 2005); and
- Utilisation of work breakdown structures during the lean design process (Isatto & Formoso, 1998; Feire & Alarcon, 2000).
- **Product Development and Design Management:** Construction process, product and design activities, key concepts include:
 - Improving construction design and processes (Melhado, 1998);
 - Development integrating elements of the product and process (Tsao & Tommelein, 2001);
 - Highlighting and incorporating concurrent engineering strategies (Kamara, 2003); and
 - Incorporating target costing as part of the construction process (Ballard, 2006; Robert & Granja, 2006).
- **Supply Chain Management:** Addresses parties involved the supply chain. London (2004) identified the central concepts of lean supply chain management to include waste elimination and workflow improvement.
- **Relational Management:** Addresses issues such as leadership, communication, cultural relationships and information sharing.

The identification of primary and secondary lean contexts assists in establishing the known awareness of lean construction across construction industries as well as key movements of lean theorisation. London & Kenley (2001) in their review of industrial organisation economic supply chain approaches for construction note the lean movement first occurred during the early 1990's. The authors also note that since this time lean principles and lean strategising have successfully been diffused and documented in United States, United Kingdom and European construction industries. Despite the diffusing of lean within construction industries across the world, the lean movement in Australia is not as well documented or widely acknowledged. There is evidence of lean research being undertaken in Australia with Marosszeky, Zuo, Zillante, Davis and Ross as the most notable researchers associated with lean. Further evidence of Australian focused research into lean theorisation is present within the newly formed conference Lean in the Public Sector; the latter researcher Ross aligns lean philosophy to project alliancing. The alignment of lean philosophy and principles of project alliancing was part of (unpublished) undergraduate research undertaken by Chesworth in 2007. The method and approach of this research has been used as a basis in which to further understand the extent of lean awareness within the Australian construction industry.

METHODOLOGY & APPROACH

A quantitative methodological approach underpins the investigation concerning the extent of lean awareness and understanding within the Australian construction industry. Undertaking a quantitative approach simply refers to the collection and analysis of numeric data through the utilisation of statistical techniques (Teddlie & Tashakkori, 2009). The nature of such quantitative research is guided by positivism

and deductive stances enabling the research investigations to be conducted independently, objectively and value free (Snape & Spencer, 2003).

The focus of the data collection is towards all major Australian construction industry sectors and understanding the extent of lean awareness and understanding. The focus of the data collection is towards all major Australian construction industry sectors and understanding the extent of lean awareness and understanding. The purpose of the questionnaire is to provide a broad snapshot of lean awareness and understanding within the Australian Construction currently. The basis of this phase of research will be used as a point of reference for further studies into lean awareness and understanding. The study will also be used as a point of reference to further research and investigate processes of lean implementation and the impact of implementation on the culture of organisations undergoing a lean transformation.

The Australian Construction Industry and Construction Forecasting Forums identify the main sectors of the Australian construction industry to include residential building, non-residential building (including commercial and industrial) and engineering sectors. The nature of the research is directed towards lean awareness in residential and non-residential building sectors and as such a questionnaire tool has been developed to reflecting these residential and non-residential building sectors (refer to appendix). Engineering sectors of the industry will be reflected in the survey tool under the categorisation of other. Also included in the category of other are construction material suppliers and infrastructure sectors. This has done as some construction organisations partake in a wide range of construction works. This study is primarily concerned with understanding lean awareness and levels of lean understanding in relation to the primary means of construction and project delivery of Australian organisations.

The questionnaire structure and content was developed and supported through an extensive literature review and analysis of lean construction and production principles. The review and analysis of lean literature identified 23 lean principles known to be prominent across the secondary contexts forming the theory of lean construction and production. The secondary contexts with which the principles present in the questionnaire emerged included *Production System Design*, *Product Development and Design Management* and *Supply Chain Management*.

The identified lean construction and production principles emerging within literature were slightly rewritten as a means to simplify potential awareness and understanding. This was done as a means to reflect potential non-principle awareness levels of participants while allowing respondents to understand the principles in more layman terms. This was done to allow respondents to understand the principles in more layman terms.

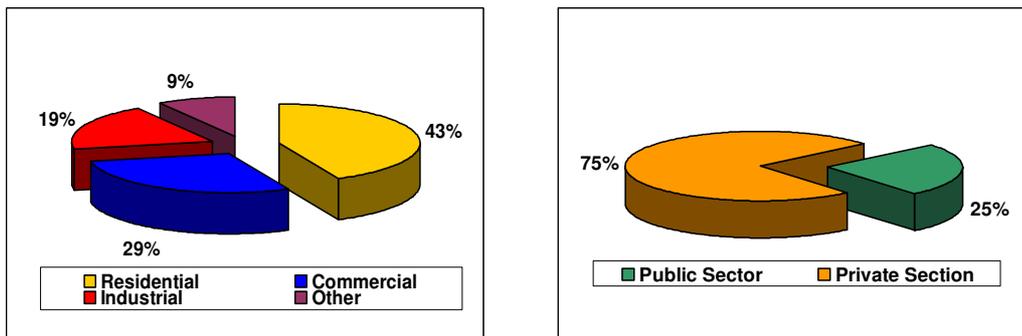
Data for the study was collected utilising an anonymous electronic questionnaire managed through an external website sent out to 1,898 randomly selected construction organisations. The randomly selected 1,898 organisations are representative of 10% of Australia's construction industry entities and were identified through national directories, the share market, organisational specific websites and the Australian Contractors Association. 804 of the organisations responded providing a 42% response rate for the questionnaire. The questionnaire results will now be discussed.

RESULTS

The distribution of the questionnaire encompassed small to large residential, commercial and industrial contractors and subcontractors across public and private construction sectors, this has provided a more unique perspective to emerge. The total questionnaire response rate was 42% or 804 construction organisations. Of the questionnaires received:

- 346 or 43% were from organisations primarily working within the residential building sector;
- 233 or 29% were from organisations primarily delivering commercial projects within the non-residential building sector;
- 153 or 19% were from organisations primarily delivering industrial projects within the non-residential building sector; and
- 72 or 9% were from organisations primarily delivering construction projects including engineering and infrastructure identified for the purpose of the research in the other category.

The results are represented in figure 1.1a *Sub-Sector Response Rates*. Furthermore of the respondents 201 or 25% of the organisations are identified working primarily in the or as public sector entities, with 603 or 75% of the organisations are identified as working primarily in the or as private sector entities, this is represented in figure 1.1b *Sector Response Rate*).



Figures 1.1a and b: Sub-Sector Response Rates and Sector Response Rates

Figures 1.2 further breakdowns the sector response rates according to the participant percentage response for each sub-sector forming the investigative focus of the study, as identified in figure 1.1a *Sub-Sector Participant Breakdown*. The further breakdown is representative of whether the organisational environment is identifiable to the Australian Bureau of Statistics (ABS), 1292.0 - Australian and New Zealand Standard Industrial Classification (ANZSIC) classification of organisational size and Wood et al (2001). Under 1292.0 ANZSIC, chapter 2, division E *Construction*, subdivision 411 (Building Construction) and subdivision 412 (Non-Building Construction) organisation size is classified as:

- Small – an organisation that is no larger than 20 employees but no less than 5 (ABS, 2001);

- Medium – an organisation that is no larger than 149 employees but no less than 50 full time employees (ABS, 2001);
- Large – an organisation that larger than 150 employees (Business Online Australia, unknown); and
- Multinational – an organisation with extensive international operations (Wood et al, 2001).

Figure 1.2 *Sector Participant Breakdown* shows a variety of response rates to the questionnaire across all the study range sectors. The sectors of residential-building and non-residential building (commercial) as defined within the study accounted for 72% or 579 of total response participants. Such a large response rate within these two industry sectors highlights an overall general awareness of the presence of lean principles and tools within the private sector of the Australian construction industry. Table 1 *Australian Levels of Lean Awareness* further breakdown the questionnaire responses inline within the questionnaire document (refer to appendix 1).

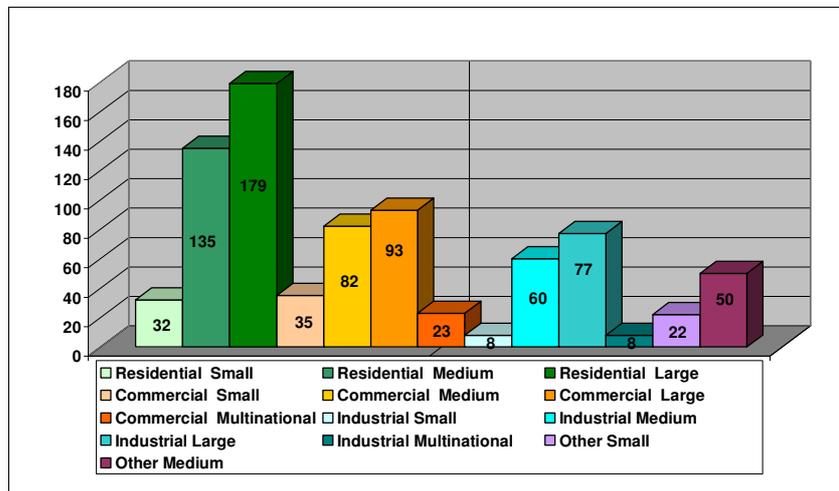


Figure 1.2: Sector Participant Breakdown

Table 1 *Australian Levels of Lean Awareness* identifies each of the 23 lean principles which formed the questionnaire (refer to appendix 1). The table also includes further definitions of each principle and principles grouping. Principal response rates (identified as a percentage) for each of the 23 principles are represented across all sectors. Dominant responses of ‘yes’ are recognised as a awareness or marked with a green cross where as dominant or combined ‘no’ or ‘unsure’ responses are recognised as unawareness or marked with a red cross. It should be noted that corresponding numbers are reflected of the overall participant response and not each sector and sub-sector.

Table 1: Australian Levels of Lean Awareness

Principle & Principle Grouping	Lean Awareness Level			
	Res	Com	Ind	Oth
Production System Design <i>Product specific design of systems to assist in the improvement of goal delivery</i>				
Management control with Last Planner <i>Construction scheduling programme</i>	X Y=7% N/U=93%	X Y=24% N/U=76%	X Y=59% N/U=41%	X Y=0% N/U=100%
Last Planner as an activity tool <i>Construction scheduling programme</i>	X Y=9% N/U=91%	X Y=9% N/U=91%	X Y=17% N/U=83%	X Y=0% N/U=100%
Work-flow Production Management <i>Construction scheduling tool</i>	X Y=3% N/U=97%	X Y=8% N/U=92%	X Y=39% N/U=61%	X Y=0% N/U=100%
Percentage Complete Planning Tools <i>Construction scheduling tool</i>	X Y=2% N/U=98%	X Y=9% N/U=81%	X Y=27% N/U=73%	X Y=15% N/U=85%
Look-a-head Planning <i>Construction scheduling tool</i>	X Y=11% N/U=89%	X Y=36% N/U=64%	X Y=78% N/U=22%	X Y=21% N/U=79%
Detailed Activity Planning closer to Activity Start Date <i>Construction scheduling tool</i>	X Y=11% N/U=89%	X Y=44% N/U=56%	X Y=93% N/U=7%	X Y=15% N/U=85%
Product Development & Design Management <i>The presence of specific development tools which assist in improved management</i>				
Process Breakdown <i>Construction scheduling tool</i>	X Y=5% N/U=95%	X Y=2% N/U=98%	X Y=21% N/U=79%	X Y=60% N/U=40%
Reverse Phase Scheduling <i>Construction scheduling tool</i>	X Y=3% N/U=97%	X Y=47% N/U=53%	X Y=13% N/U=87%	X Y=69% N/U=31%
Weekly Work Plans <i>Construction scheduling tool</i>	X Y=81% N/U=19%	X Y=86% N/U=14%	X Y=92% N/U=8%	X Y=26% N/U=74%
Supply Chain Management <i>Addresses the improvement of specific issues present within the supply chain particularly through communication</i>				
On/off-site seamless collaboration <i>Communicative strategy</i>	X Y=3% N/U=97%	X Y=16% N/U=84%	X Y=8% N/U=92%	X Y=29% N/U=71%
Collaborative Planning Schedules <i>Communicative strategy</i>	X Y=14% N/U=86%	X Y=25% N/U=75%	X Y=56% N/U=44%	X Y=67% N/U=33%

Table 1: Australian Levels of Lean Awareness

Principle & Principle Grouping	Lean Awareness Trend			
Supply Chain Management	Res	Com	Ind	Oth
Daily Work Meetings	X	X	X	X
Communicative strategy	Y=64% N/U=36%	Y=100% N/U=0%	Y=100% N/U=0%	Y=81% N/U=19%
Supply Chain Management	Res	Com	Ind	Oth
Weekly Work Meetings	X	X	X	X
Communicative strategy	Y=80% N/U=20%	Y=97% N/U=3%	Y=84% N/U=16%	Y=100% N/U=0%
Relational Management	Res	Com	Ind	Oth
<i>Addresses the improvement of processes through relational techniques</i>				
Team Frameworks	X	X	X	X
Relational strategy	Y=90% N/U=10%	Y=100% N/U=0%	Y=86% N/U=14%	Y=100% N/U=0%
Situational Leadership	X	X	X	X
Relational strategy	Y=94% N/U=6%	Y=90% N/U=10%	Y=15% N/U=85%	Y=10% N/U=10%
Valued/Encouraged Employee Contributions	X	X	X	X
Relational strategy	Y=6% N/U=94%	Y=28% N/U=72%	Y=92% N/U=8%	Y=74% N/U=26%
Flexible Communication	X	X	X	X
Communicative strategy	Y=18% N/U=82%	Y=45% N/U=55%	Y=86% N/U=14%	Y=100% N/U=0%
Strong Industry Standards/Regulations	X	X	X	X
Relational strategy	Y=95% N/U=5%	Y=100% N/U=0%	Y=100% N/U=0%	Y=100% N/U=0%
Long-term Organisational Commitment	X	X	X	X
Relational strategy	Y=87% N/U=13%	Y=89% N/U=11%	Y=100% N/U=0%	Y=90% N/U=10%
Knowledge Sharing	X	X	X	X
Communicative strategy	Y=34% N/U=66%	Y=85% N/U=15%	Y=72% N/U=28%	Y=74% N/U=26%
Training and Retraining	X	X	X	X
Educational strategy	Y=41% N/U=59%	Y=79% N/U=21%	Y=100% N/U=0%	Y=100% N/U=0%
Engaged Communication	X	X	X	X
Communicative strategy	Y=91% N/U=9%	Y=89% N/U=11%	Y=100% N/U=0%	Y=94% N/U=6%
Reliable Client Agreements	X	X	X	X
Contractual strategy	Y=3% N/U=97%	Y=89% N/U=11%	Y=77% N/U=23%	Y=93% N/U=7%

DISCUSSION

Three key levels of awareness arose during the analysis of the survey results:

- The first, the presence of shared awareness of lean principles;
- The second, the presence of shared non-awareness of lean principles; and
- The third, the presence of differing awareness of lean principles.

The presence of shared lean principle awareness within and across all sectors of the construction industry was present across 6 questionnaire principle groups. The presence of lean principle awareness was identifiable in day-to-day organisational and planning traits such as work meetings, team frameworks, industry standards and regulations, commitment and communication. Although these principles are generally shared throughout all sectors of the industry the nature of the principles are not specifically unique to lean thinking and implementation. Rather many of these principles are relational in practice and nature and are generally identifiable as standard industry best practice within Australian construction. The nature of the shared awareness of the more relational styled lean principles across industry sectors highlights a positive move by industry to be more focused about how projects are delivered rather than overall bottom line. This is further supported by the higher rates of private enterprises that form and are identified primarily within the residential-building and non-residential building commercial sectors. The full impact of this influence in the implementation of lean within Australia construction needs further study.

The presence of shared non-lean principle awareness was present across 4 principle groups forming the questionnaire. Such principles present within this trend included the lean last planner system as a management tool to minimise activity-to-activity links, seamless collaboration between on-site and off-site parties, work-flow production management techniques and percentage complete planning tools. The nature of these principles is more inline with the lean philosophy and the lack of awareness and presence of lean within the Australian construction environment. The lack of shared awareness of specific lean planning strategies suggests the Australian construction industry could be influenced by one of two issues, which need further investigation of lean within the Australian construction industry:

- The first that the industry is still challenged to some degree by management, collaboration and planning issues. This first issue emerges particularly due to the nature of the operative environments of the Australian construction industry. This is particularly evident in particularly the residential-building sector to be more concerned about issues related to profitability over management, collaboration and planning. Underpinning this perspective is the presence of low-barriers of entry; and
- The second that the nature of the construction industry is more adapted and suited towards temporary project relations. This second issue emerges particularly in regards to the nature of project delivery and contractual relations within the industry. Further investigation into the nature of this issue is needed to understand its impact.

The final trend emerging during the analysis was the presence of differing awareness levels of lean principles. This final trend is present across 13 principles and highlights an interesting understanding and awareness of core lean principles across Australian construction sectors. Further research and investigative analysis into

elements and issues underpinning the presence of differing lean awareness would assist in better understanding this trend.

The results have highlighted that the residential-building and non-residential building commercial sectors are have a higher presence of lean awareness to principles that specifically addressed relational and industry standards of best practice. This view is supported by the higher level of private enterprises which form those construction industry groups. It is interesting to not how these sectors are less aware of principles that specifically address and target management and planning mechanisms. This may arise also to the high levels of private enterprises which dominated the study. The non-residential building industrial and other industry sectors are identified as being more generally aware of lean principles which address management, planning, control, design, production and communicational principle groupings.

CONCLUSION

Mohan & Iver's 2005 investigative study into the identification of lean principle effectiveness within American construction provided a basis in which to explore the extent of lean awareness and understanding across the Australian Construction Industry. Mohan & Iver's study investigated the application of 41 lean principles, identifying 29 lean orientated benefits across 16 organisations in the USA. This study was specifically focused the application of lean principles and published reports of company experience, although limited the study has provided a basis in which to explore lean awareness and understanding on an industry scale. Although the implementation of lean principles is prominent and well investigated across in other construction industries such the USA, UK and Europe, the terminology is not so well known in Australia. This paper has set out to identify and investigate the extent of awareness of key lean principles across Australian construction sectors. A survey research approach was undertaken to investigate. The results of the questionnaire highlighted three key trends to be present within Australian construction concerning lean awareness and of these trends the most prominent was differing lean principle awareness levels. This third category highlighted that the industrial sector of Australian construction is more aware of lean principles than any other sector, with 17 out of 23 principles identified as a dominant 'yes'. The sector identified as other was the second most lean aware with 15 out of 23 principles identified as a dominant 'yes'. The commercial sector identified 12 out of 23 principles as a dominant 'yes' and the residential sector identified 8 out of 23 principles as a dominant 'yes'. These trends can suggest that the smaller sectors of Australian construction are aware due to sizing, management style and knowledge base, where as the larger sectors are still focused on traditional management and planning.

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