TECHNICAL NOTE

LEVEL OF AWARENESS ON LEAN THINKING CONCEPT IN CONSTRUCTION AMONG HIGHER LEARNING STUDENTS IN MALAYSIA

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Abstract: Lean construction has been implemented throughout the construction industry in order to increase the profit by minimising non-value adding activities. Lean is a technique that manages the construction process to eliminate wastes, reduce costs, and deliver projects on time by breaking the construction projects to smaller parts of activities. Previous studies found that the most critical barriers to implementing lean construction approach in Malaysia are lack of knowledge on the lean concept and lack of commitment from management. The aim of this study is to investigate the potential barriers in implementing lean thinking within the construction industry in the future in Malaysia. In order to implement lean thinking in construction activities, involved parties should understand the lean principles, lean construction techniques and causes of waste. As a result, postgraduate students from the faculty of civil engineering and built environment were evaluated regarding their knowledge on lean construction and management commitment. The data were collected through a questionnaire survey distributed to 140 postgraduate students who involved in the construction industry afterwards. The results showed that construction management students are familiar with the concept of lean thinking. However, there is a need to enhance the knowledge of students from the faculty of civil engineering and built an environment of UTM in terms of lean thinking concepts. In terms of management commitment, the construction management students are entirely aware of their responsibilities in implementing lean construction.

Keywords: *Lean construction, barriers, level of knowledge, lean management*

1.0 Introduction

The lean production concepts were established by Toyota Motor Company in Japan in the late 1950s and early 1960s. Ohno has developed a simple set of objectives for production system designing: produce the car based on specific customers' requirements, deliver it instantly, and not retain cars in inventories or intermediate stores

(Dombrowski & Mielke 2013). Limited natural resources, lower demand, development of just in time (JIT), quality movement, limited space, additional factors, and mass production practices are the factors associated with the beginning concepts of lean production (Marhani *et al*., 2012; Lukowski, 2010; Womack & Jones, 1994). The goal of lean production is described by Biswas and Sarker (2008) as "to get the right things to the right place at the right time, the first time, while minimising waste and being open to change."

The aim of lean construction (LC) is to eliminate the share of non-value adding activities, reducing waste, increasing productivity and safety for meeting the client's requirements of the construction industry (Marhani *et al*., 2012). Several definitions of lean construction have been revealed from the literature review. The majority of researchers highlighted that minimising construction waste and meeting client's requirements are the main concepts of lean construction (Aziz & Hafez, 2013; Bertelsen & Koskela, 2004; Cullen *et al*., 2005; Howell, 1999; Salem *et al*., 2006; Dickson *et al*., 2009). Kim and Park (2006) have stated that LC allows the organisation to eliminate waste, reduce costs and deliver projects on time due to achieving a balanced use of resources. Lean Construction Institutes (LCI) highlighted that the main objectives of lean construction are to maximise value and minimise the wastage through a specific technique and applying them in the new project delivery. LCI defined that LC is a new approach that concentrated on the maximisation of the construction project's value as a production management based system. Maximising project's value includes cost saving, ensuring high quality of the end product, increasing the safety of the construction workers and improving the confidence level; and enhancing the sustainability of the project itself (Aziz & Hafez, 2013).

Eleven basic principles for lean construction have been introduced by Koskela (2004) including: reduce the share of non-value adding activities, increase output value, reduce variability, reduce the cycle time, simplify by minimizing the number of steps, parts and linkages, increase output flexibility, increase process transparency, focus control on the complete process, build continuous improvement into the process, balance flow improvement with conversion improvement and benchmark are the main principles for lean production (Koskela, 1992; Bashir *et al*., 2011). In general, the principles apply both to the total flow process and to its sub-processes. Womack and Jones have simplified the LC principles stated by Koskela into five LC principles, which are specified value from client's perspective, mapping the value stream, make the value-creating flow, establishing client pull at the right time, and pursue perfection for continuous improvement (Womack & Jones, 1994; Bashir *et al*., 2011). Moreover, it is worth mentioning that, these five principles have a positive performance in total flow process and its sub-process in the construction industry (Bashir *et al*., 2011; Lim, 2008; Marhani *et al*., 2012).

There are many key concepts or tools of LC throughout the project phases that can be accepted by the stakeholders. Koskela proposed three principles of production philosophy that can be used at early project phase; which includes management philosophy, manufacturing method, and various tools (Bashir *et al*., 2011). Moreover, Alinaitwe (2009) has simplified and depicted the key concepts of LC included just in time (JIT), total quality management (TQM), business process re-engineering (BPR), last planner system (LPS); value-based management (VBM) and teamwork. Yahya and Mohamad (2011) concluded that LC is a practical method for managing and improving the construction process; hence, profitability can be delivered by using the right principles and resources as well its ability to deliver things right the first time. In general, any losses produced by activities that generate direct or indirect costs but do not add value to the product from the point of view of the client can be called "waste." Waste is measured in terms of costs; however, other types of waste are related to the efficiency of the processes, equipment or personnel, and are more difficult to be measured because the optimal efficiency is not always known (Formoso *et al*., 1999; Womack & Jones, 2010). Alarcon (1997) defined the value adding and non-value adding activities as follows: Value-adding activities; Those which convert materials and/or information in the search to meet client's requirements and Non -value adding activities (waste); Those which are time, resource, or space consuming, but do not add value to the product. Formoso *et al*. (1999) proposed the main classification of waste, which includes over production, substitution, waiting time, transportation, processing, inventories, movement and production of defective products.

1.1 Barriers in Lean Construction

Based on the literature, it can be summarised that there are seven categories of barriers in implementing lean construction including: managerial, technical, human attitude, the process of LC, educational, government and financial are the main barrier aspects in implementing lean thinking in construction Marhani *et al*. (2013). According to Abdullah *et al*. (2009) and Mossman (2009), lack of commitment from top management of a company is one of the main barriers to implementing LC. This barrier is interrelated with various aspects of top management support in an organisation. It was found that many construction projects are facing a lack of support from the top management (Kim & Park, 2006). In addition, lack of communication among stakeholders occurs in the construction projects (Abdullah *et al*., 2009). The stakeholders involved in the construction industry face several problems in adopting LC concept if they do not receive continued support from top management.

In addition, the lengthy implementation period of LC process is considered as the barriers in LC implementation. Based on the study conducted by Kim and Park (2006), it was discovered that the implementation of LC in construction projects results in many meetings and information needed for discussions. Sufficient training to enable the stakeholders involved in the construction projects is needed to give the necessary

knowledge and expertise in implementing LC concept. Inadequate exposure to the requirements for LC implementation is another barrier in implementing lean construction (Lim, 2008). Understanding the concept and principles of lean thinking and also the key concepts required to undertake the LC concept and the balance between them is essential to be given in training (Abdullah *et al*., 2009; Alinaitwe, 2009). Furthermore, Abdullah *et al*. (2009) stated that educating and training the employees in an organisation may take time and need additional efforts. Therefore, top management has to play an important role in developing the educational understanding and expanding subordinate training of LC concept. According to Abdullah *et al*. (2009), there are nine barriers related to implementing lean construction in Malaysia construction industry. Lack of attentiveness and commitment from top management and Difficulties in understanding the concepts of lean construction are the most critical barriers. This study focuses on the two major problems to investigate the probability of occurrence these barriers, which related to educational issues, in the future.

2.0 Methodology

All the respondents were selected from the postgraduate levels, which include master degree and PhD students. The questionnaires were distributed to 140 pre-selected respondents from the faculty of civil engineering and built environment in UTM. The questionnaire survey is selected as it is a reliable and easily reachable method to get feedback from the respondents. It gives in-depth and accurate feedback on the respondent perception of the service or products. For this study, 140 questionnaires are provided and all these questionnaires distributed among graduated and posts-graduated students and collected at that time. Therefore, there is not any rejected questionnaire in this study. The focus of this study is to the current students as the next generation to contribute to the construction industry. Hence, their views indicate the construction industry orientation in terms of implementing lean thinking and management development in the future. The students were categorised based on their field to understand the different views among them. The population of respondent groups is shown in Table 1.

Table 1: Respondents' quantity and educational position

Faculty	Respondent qualification	Quantity	Percentage
Civil engineering	Master	70	87.5%
	PhD	10	12.5%
	Total	80	100%
Built environment	Master	52	86.7%
	PhD	8	13.3%
	Total	60	100%
Total civil engineering and built environment	Master	122	87.1%
	PhD	18	12.9%
	Total	140	100%

The preliminary structure of this questionnaire consists of three parts; part "A" for respondent position (their level of education and also the education field), part "B" for level of students' knowledge on lean construction (concept and lean principles and techniques), and part "C" for the management support factors which might not considered in implementing lean construction. The questionnaire includes fill-in-the-blank, yes-no, multiple-choice questions, and five-point Likert scale. In the first part, the participants were asked to answer the questions about their personal educational positions. In the second part, which contains a total of 33 questions, the respondents answered yes-no and multiple-choice questions and the possibility to answer 'not sure' for the last question. The 5-point Likert scale was used to design the third part of the questionnaire. Five points of very ineffective, ineffective, neutral, effective, and very effective, can be applied for the questionnaire for part "C". The basis of the questionnaire in knowledge assessment part (B) was developed by the concept, principles and techniques which gathered from the literature review. The Likert scale questions in part "C" is based on fundamental principles of lean leadership.

2.1 Data Analysis

According to Pichler *et al*. (2014), the level of knowledge can be evaluated by asking respondents about their level of understanding on specific issues. Thus, the scored percentages from the right answers exhibit their knowledge. In this study, the collected data from yes-no and multiple questions regarding lean concept, principles, and techniques, which presented the students' level of knowledge on lean construction, has been analysed using SPSS. Collected data from the Likert scale questions in part "C", which related to learning leadership, was analysed by applying the Average Index (A.I) analysis. AI is aimed at getting the average response to the questions in the questionnaire survey in terms of fractions of the Likert scale of 1 to 5, and can be evaluated based on index classification in Table 2. Moreover, One-Sample t-Test, Chi-Square Test, Reliability Analysis (Cronbach's α) and analysis of the variance model has performed to test the reliability of the respondents' answer.

Table 2: Average Index Analysis (A.I) and level agreement

Average Index	Level of Effectiveness of Evaluation
1 .00 ≤ Average Index ≤ 1.50	Very Ineffective
1.50 < Average Index ≤ 2.50	Ineffective
2.50 < Average Index ≤ 3.50	Neutral
3.50 < Average Index ≤ 4.50	Effective
4.50 < Average Index ≤ 5.00	Very Effective

3.0 Results and Discussion

Results show that none of the students from the faculty of civil engineering and built environment is really familiar with the lean construction concept. The students from these programs were found not really familiar with the lean concept and the construction wastes that might occur during the execution of a project. Following sub-sections indicate the responses of implementing lean thinking within the construction industry, which represents the knowledge of construction management students in both master and PhD level on lean construction. Based on the results, most of the students do not have adequate knowledge on associated lean construction techniques, as the next generation of construction industry players.

3.1 Level of Knowledge on Lean Thinking

There are several important aspects of lean thinking in construction that the parties involved should be aware of them such as principals of lean production and construction, causes of waste in the construction industry and Lean construction techniques. In the process of providing the questionnaire, the study has tried to evaluate all these aspects in separate parts as follows.

3.1.1 Principles of Lean Production

Many researchers highlighted that the first step of using lean construction is understanding the principles of lean production, and all the principles of lean construction are originated from lean thinking in production. Figure 1 indicates that the students' knowledge on increase process transparency (85%), built a continuous improvement on the processes (85%), reduce none-value adding activities (82%) and reduce the cycle time (78%), is more than other principles. Most of the students do not consider customer requirements, balance flow improvement and simplify by minimising steps and parts.

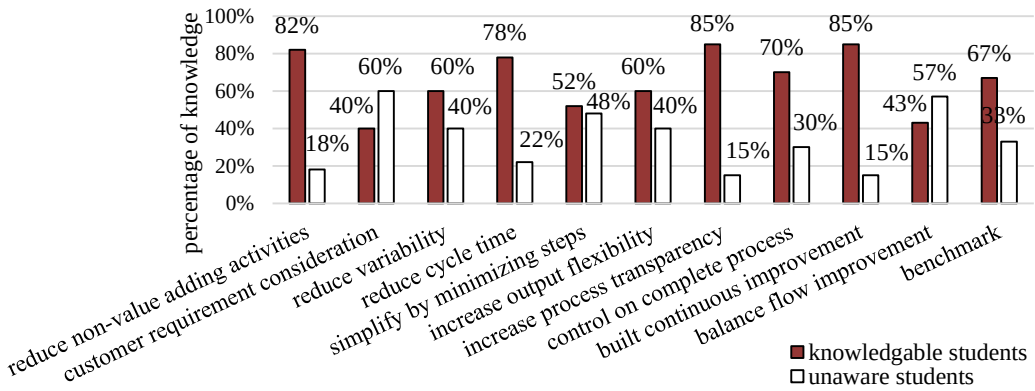

Figure 1: Knowledge of lean production principles

3.1.2 Causes of Waste in Construction

Reducing the wastage of construction industry is always a critical issue that needs to be more investigated. Waste reduction is the main objective of lean thinking in the construction industry. In order to use the techniques of lean thinking to control the wastages; the first step is to know where the wastages are, and which involved parties are responsible for this wastages. As a result, the respondents were evaluated in the level of understating related to waste in Malaysia's construction industry. The results of knowledge on each waste recourses show that most of the construction management students were aware of the sources of waste during construction. Figure 2 illustrates the percentage of knowledge on each waste resource. Indeed, their waste awareness is more on the phase of inventories, production of defective products, processing and waiting time with the percentage source of 97%, 91%, 82% and 73% respectively.

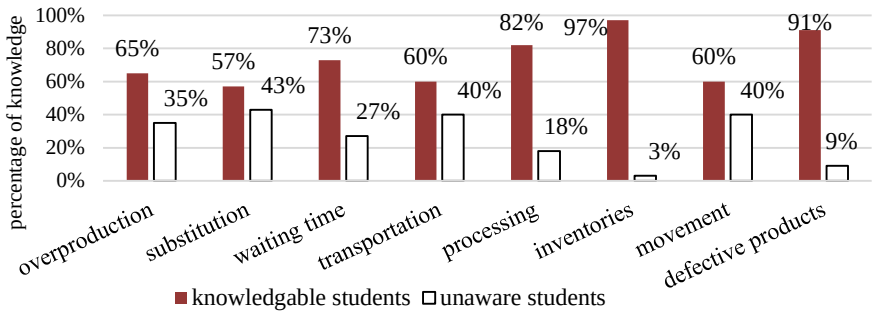

Figure 2*:* Knowledge on each waste resources

3.1.3 Principles of Lean Construction

The first step of implementation of lean thinking in construction is to understand its principles. The intention of this part is to evaluate the knowledge of students on lean construction principles. The result of this part is shown in Figure 3. Indeed, waste elimination, improve achievement by measurements, coordination and clarity of responsibility, and customer focus are the lean principles, which most of the students have knowledge of them. On the other hand, end users benefiting from the lowest optimum cost (64%) and supplier involvement to achieve integration (53%) are the principles that respondents do not consider.

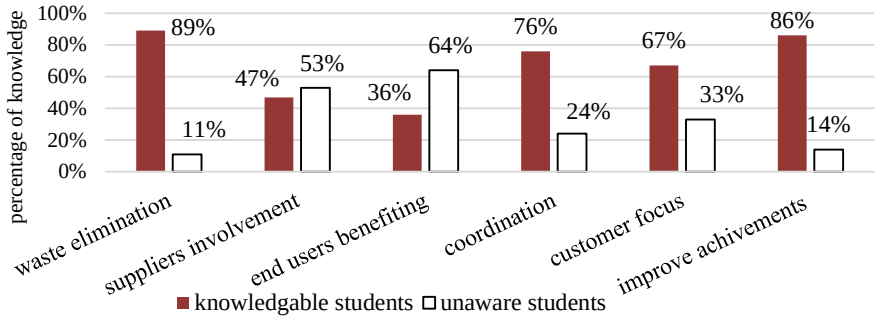

Figure 3: knowledge on lean construction principles

3.1.4 Lean Construction Techniques

There are several techniques (Business process Re-engineering, Just-In-Time, Concurrent Engineering, Value Based Management, Last Planner System and Teamwork) can be used in lean construction, and each of them is practical in a specific period of the life cycle of a project. In this part, respondents were asked to highlight the practical phase related each technique. Figure 4 indicates the percentage of knowledge on all associated techniques. Approximately half of the students recognised the proper stages for implementing just-in-time, teamwork, total quality management, and concurrent engineering. However, based on the results, the respondents were not familiar with lean construction techniques. The students were found very unfamiliar with last planner system (9%), value-based management (16%) and business process re-engineering (27%) respectively.

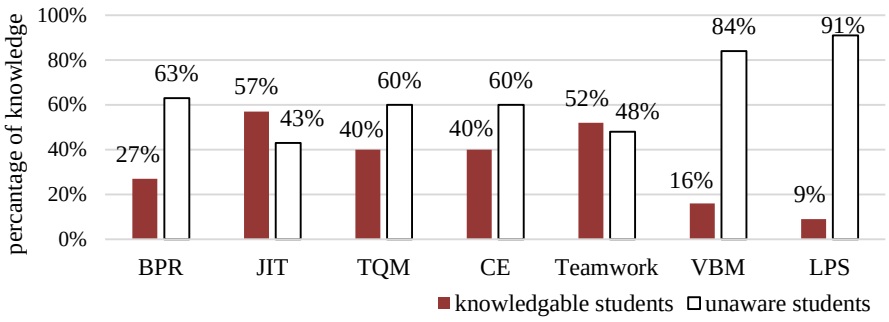

Figure 4: knowledge on lean construction techniques

As mentioned before, none of the students from other programs in "civil engineering" and "built environment" has familiarity with lean thinking. Therefore, the final results of the level of knowledge on lean construction merely focused on the graduated and post-

graduate construction management students. It can be understood that level of knowledge of construction management students on lean thinking in construction based on their knowledge of the lean concept, principles and associated techniques. Based on the results, most of the students do not have adequate knowledge on associated lean construction techniques, which is the greatest weakness of them as the next generation of participants in the construction industry.

3.2 Lean Leadership and Management Commitment

As a respondent in this part, 53 construction management students reveal their ideas on five factors in each five principal categories. When data collected, three different tests have been that were used to determine the reliability of the data. The flow or sequence of the test to prove the reliability of the data was started off using One-Sample t-Test to analyse the data whereby if the p-value is ≤0.05 then the data were used for the next test if the p-value is >0.05 then the data will be omitted from the next test. Thus, realistic of data (Chi-Square Test) has been used to check the liability of the data with the remaining data which passed the first test whereby if the P value is ≤0.05 than the data were used for the next test if the P value is &0.05, then the data will be omitted from the next test.

Lastly, Cronbach's α was applied. The remaining data which passed the second test was checked if the p value is equal or more than 0.7; the data were proved to be reliable and error free. Two factors were rejected in One-sample t-Test and Chi-Square Test as indicated in Table 3 and 4. It could be concluded that among three mentioned tests, all the factors are significant and will be used for further analysis except "providing no-blame culture in organization" from first category of principles and "encourage subordinators and motivate them" form third one.

3.2.1 A.I. of Lean Management Factors

This study calculated A.I for each factor related to management support elements and lean leadership principles to figure out the level of agreement of students about the effectiveness of these factors that a manager has to be capable of doing in order to support the organisation and achieving the project goals. The calculation is done by SPSS 21, and results are shown in Figure 5, Figure 6, Figure 7, Figure 8, and Figure 9 for each category of lean leadership principles.

Table **Error! No text of specified style in document.**: results of performing chi-square tests on improvement culture factors

	Test Statistics				
	Striving to perfection	Request challenging	Find failure root causes	Collaboration among parties	No-blame culture
Chi-Square	43.075[a]	63.887[b]	40.113[b]	19.736[b]	43.132[b]
df	3	4	4	4	4
Asymp. Sig.	.000	.000	.000	.001	.079*

** Statistical significance P>0.7*

Table 4: results of performing one sample t-test on lean leadership factors

	One-Sample Test			
	Test Value = 3			
	t	df	Sig. (2-tailed)	Mean Difference
Striving to perfection	13.211	52	.000	1.321
Request challenging	2.771	52	.008	.283
Find failure root causes	4.320	52	.000	.528
Collaboration among parties	1.473	52	.001	.208
No-blame culture	1.267	52	.211*	.170
Having technical knowledge	14.729	52	.000	1.264
Carrying out several tasks	4.784	52	.000	.679
Develop routine	7.805	52	.000	.868
Making trust	.904	52	.037	.151
Competency to guide subordinators	1.156	52	.025	.170
Explaining complex tasks	4.582	52	.000	.472
Building communication	5.105	52	.000	.774
Ask to improve performance	1.798	52	.048	.208
Supportive communication	2.942	52	.005	.415
Encourage subordinators	1.564	52	.124*	.245
Closely monitoring	7.506	52	.000	.792
Getting first-hand information	-1.694	52	.036	-.245
Take temporary countermeasures	.409	52	.038	.057
Revising failed process	8.996	52	.000	1.189
Seeking long-term solution	9.237	52	.000	1.151
Giving order and clarify procedures	4.696	52	.000	.623
Instruction to meet clients' need	1.501	52	.014	.208
P-D-C-A to achieve ultimate goal	1.434	52	.016	1.415
Monitoring continuous improvement	2.475	52	.017	.340
Accomplishing managed goal	2.335	52	.023	1.321

** Statistical significance P<0.05*

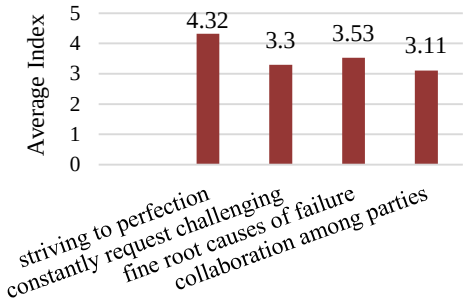

Figure 5: Average Index of improvement culture factor

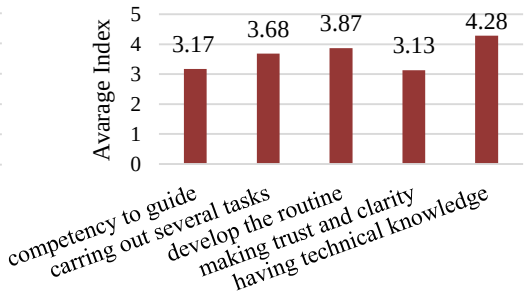

Figure 6: Average Index of self-development factors

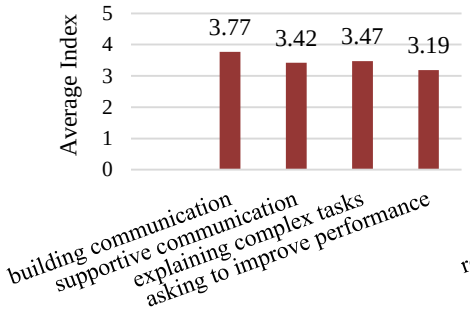

Figure 7: Average Index of qualification factors

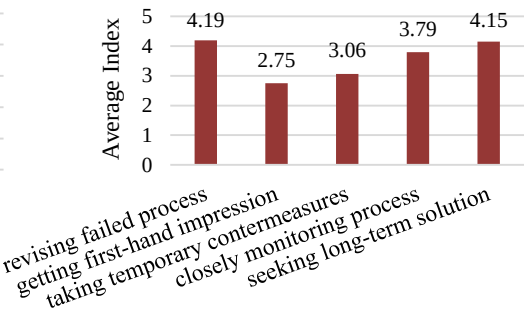

Figure 8: Average Index of stand in place factor

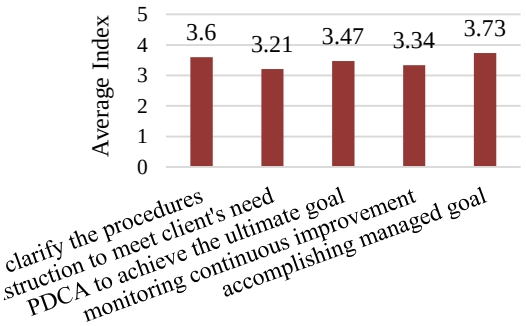

Figure 9: Average Index of target management factors

Based on the obtained A.I., the final results can be categorised as shown in Table 5. The construction management students as the respondents of this study rate these factors as the most effective factors of lean leadership principles for implementing the lean construction.

Table 5: most effective factors of lean leadership principles

Lean leadership principles	Related factors	Average Index
Improvement culture	Striving to perfection	4.32
	Find root causes of failure	3.53
	Having technical knowledge	4.28
Self-development	Ability to carry out several tasks	3.68
	Develop the routine, set priorities	3.87
Qualification	Building communication	3.77
Stand for real place	Closely monitoring the processes	3.79
	Revising the failed process	4.19
	Seeking long term solution	4.15
Target management	Giving order, clarify procedures	3.60
	Accomplishing managed goal	3.73

4.0 Conclusions

Barriers for lean implementation in the construction industry could be overcome if all the involved parties have been fully thought and focus on the most important factors that hinder the effectiveness of implementing lean construction in Malaysia. “Lack of knowledge on lean construction” and “lean leadership or commitment” are the most critical barriers in Malaysia's construction industry. Merely the students from the construction management program know about lean thinking in construction, and their weakness is most on lean technical principles. In fact, around 50 percent of them have adequate knowledge about lean thinking. Thus, it can be concluded that the understanding of lean thinking is not sufficient for students in the postgraduate level of study.

In terms of lean commitment, the students who supposed to be involved in the construction industry as a manager in future are aware of the responsibilities and commitments of a manager. It shows that they have been thought at a high level in terms of what a manager has to do throughout courses in master degree. In order to enhance the level of knowledge of parties involved in the construction industry, learning and training in universities could be the first step, and it is can be seen that none of the students from the faculty of civil engineering and built environment knows about lean thinking except students from the construction management program. Although, construction management students know about lean thinking, their knowledge is not enough. As a result, focusing on some subjects including lean thinking is urgent. Especially for those who do not know at all about this critical issue and for construction management students, focusing more on the techniques and their advantages is required.

This study showed that construction management students before joining the construction industry have knowledge about the issues related to management support;

however, there is still a lack of commitment from management in construction industry. Consequently, there are two different scenarios in the case of current lacked of commitment; first, they have not been effectively thought in the past, and second, there are some other factors related to management support during managing a project that can affect directly on the management behavior. Moreover, further studies can focus on the issues that occur during a project that may contribute in decreasing the commitment of the managers.

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