An Investigation into the Evolution of Lean Construction, Education in Indian Industries and Universities

Sebin Antony, K.S. Anandh, B. Siddharth

Abstract: ***Even though lean construction concepts are successfully implemented over the past two decades and its benefits are harnessed in many construction projects all over the world, its adoption in Indian construction industries and universities are sparse. There are many challenges to the implementation of lean construction concepts. The aim of this paper is to investigate the factors that affect the adoption of lean construction concepts in Indian industries and universities. The outcomes revealed that training of personals was a major factor which affected the adoption of lean construction. Other factors included additional cost expenditure, lean culture in the organization, teaching methodology, technical skills and awareness. Thus, this study could be used for a better understanding of the factors affecting lean construction adoption and for further research on how these challenges can be tackled.***

Keywords: lean construction, lean construction education, industry, academia, lean adoption factors.

I. INTRODUCTION

The Indian construction industry is the second largest contributor to the country's economy by creating investment opportunities across various sectors related to it. The construction industry gives employment to a large population which involves not only professionals but also skilled and unskilled labors irrespective of their gender. Lean construction is considered to be the most efficient tool to increase productivity and efficiency in construction projects by academics and professionals. Implementation of lean management is said to remove 8 types of wastes such as: transport, motion, inventory, overproduction, waiting, defects, over-processing and talent. This adaptation of lean construction can be made possible only if the academia and industry work hand-in-hand. The skills and qualities required for a person to get selected for a job in a company that has already implemented lean or are trying to adopt lean in near future should be first enquired and then the universities must train students to acquire these skills. Also the adoption of lean construction in academia and industries face many barriers.

II. METHODOLOGY

A detailed study was done to identify the factors which impact the adoption of lean construction education in both academia and industry. These factors were used to frame a systematic questionnaire. Based on the samples received from the questionnaire, analysis was carried out using Statistical Package for Social Sciences (SPSS) Version 21.0 to find out the impact of these factors on the adoption of lean construction, education in industry and academia.

The respondents in case of industry were project managers, site engineers and project engineers. Whereas, in case of academia the respondents were professors and assistant professors. The respondents were reached through mails, face to face interviews, etc. Out of the 200 samples distributed 160 responses were received with a response rate of 80%.

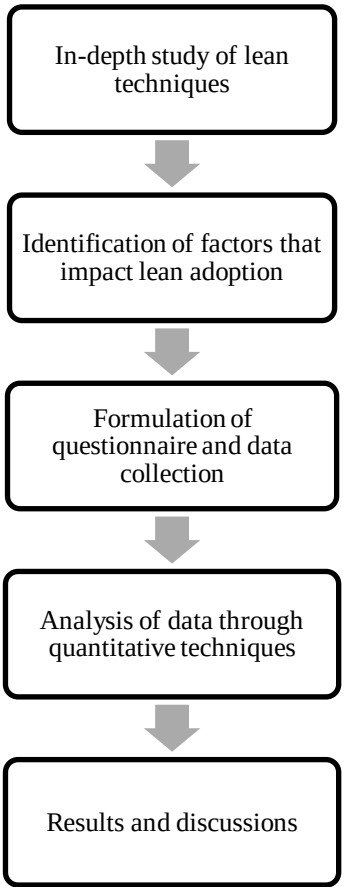

Fig.1:Flowchart of Methodology

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III. EXPLANATION OF ANALYSIS METHOD

Descriptive statistics are brief descriptive coefficients that summarize a given set of data, which may be a representation of the totality or a sample of a population. Descriptive statistics are broken down into measures of central tendency and measures of variability. Measures of central tendency include mean, median, and mode, while measures of variability include standard deviation, variance, minimum and maximum variables, and kurtosis and asymmetry. In this study descriptive statistics is done for both industry and academia separately.

Correlation analysis is a statistical evaluation method used to study the strength of a relationship between two numerically measured continuous variables. This type of analysis is useful when a researcher wants to establish if there are possible links between the variables. If a correlation is found between two variables, it means that when there is a systematic change in one variable, there is also a systematic change in the other; the variables change together over a period of time.If there is a correlation, depending on the measured numeric values, this can be positive or negative. A positive correlation exists if one variable increases simultaneously with the other, that is, the high numerical values of one variable are related to the high numerical values of the other. A negative correlation exists if one variable decreases as the other increases, that is, the high numerical values of one variable are related to the low numerical values of the other.

The relative importance test is a method that helps you determine what factor is more important for people by asking them questions designed to simulate real tradeoffs. People never accept compromises unless they have to make a selection. Since perfection does not exist, people are content with the best possible option. By asking the person to choose, you collect more precisedata about how they would react to a same choice in the real world. The more questions each person asks, the more you will be able to judge the relative importance of each benefit. The relative test helps you identify the factors you need to focus on to make lean more adoptable.

IV. RESULTS AND DISCUSSION

A. Demographic Profile

Table 1 shows the demographic details of the respondents.

Table 1: Demographic Details

Sl. No	Particulars	Frequency	
		Industry	Academia
	Gender		
1	Male	55	54
2	Female	25	26
	Age Group		
1	18 – 28	47	48
2	28 – 38	14	26
3	38 – 48	12	2
4	48 – 58	7	4
	Designation		
1	Site Engineer	32	–
2	Planning Engineer	6	–
3	Project Engineer	20	–
4	Design Engineer	12	–
5	Project Manager	10	–
6	Assistant Professor	–	66
7	Associate Professor	–	6
8	Professor	–	8

B. Reliability Analysis

Table 2 and 3 clearly shows that for all the items the Cronbach's Alpha is above 0.7. Thus it can be concluded that the survey instrument developed and applied in this study is valid and can be suitably administered with the samples of respondents of the study.

Table 2: Reliability Analysis (Industry)

S. NO.	Scale Factors	No. of Items	Cronbach's Alpha
1	Awareness	5	0.898
2	Technical Skill / Training	5	0.786
3	Cost Expenditure	5	0.888
4	Lean Culture	5	0.842
5	Employees Attitude	5	0.764

Table 3: Reliability Analysis (Academia)

S.NO	Scale Factors	No. of Items	Cronbach's Alpha
1	Awareness	5	0.833
2	Faculty Training Programmes	5	0.801
3	Teaching Methodology	5	0.859
4	Curriculum Framework	5	0.752

C. Descriptive Statistics

The descriptive statistics of the data collected from the industry respondents of the study is shown in Table 4. From the Table 4, it is very clear that the Technical Skill / Training (4.35) related to Lean concepts was the top rated factorfollowed by Cost Expenditure (4.10) in the application of Lean in construction projects.The level of awareness (3.85) on Lean in construction was found to be average. Employees are skeptic about the Lean in construction and Employees Attitude (3.62) toward Lean implementation was low.

The prevalence of culture (3.76) to accept Lean was also not favorable to a large extent. The values of Skewness and Kurtosis was within the prescribed limits which indicates that the data are normal for further statistical analysis.

Table 5 shows that faculty training was programme (3.96) was the top rated factor followed by teaching methodology.

Table 4: **Descriptive Statistics (Industry)**

Factors	Minimum Statistic	Maximum Statistic	Mean	Std. Deviation	Skewness		Kurtosis	
					Statistic	Std. Error	Statistic	Std. Error
Awareness	3.20	4.80	3.85	0.416	0.358	0.269	-0.736	0.532
Technical Skill / Training	3.40	4.80	4.35	0.332	-0.686	0.269	-0.258	0.532
Cost Expenditure	2.80	4.80	4.10	0.423	-0.557	0.269	0.796	0.532
Lean Culture	2.20	5.00	3.76	0.621	0.128	0.269	-0.092	0.532
Employees Attitude	2.80	4.80	3.62	0.461	0.280	0.269	-0.187	0.532

Table 5: **Descriptive Statistics (Academia)**

Factors	Minimum Statistic	Maximum Statistic	Mean	Std. Deviation	Skewness		Kurtosis	
					Statistic	Std. Error	Statistic	Std. Error
Awareness	3.00	4.80	3.63	0.39	0.248	0.269	0.086	0.532
Faculty Training Programmes	3.00	4.60	3.96	0.35	-0.539	0.269	-0.103	0.532
Teaching Methodology	1.80	4.80	3.80	0.51	-0.739	0.269	1.754	0.532
Curriculum Framework	3.00	4.80	3.78	0.46	0.212	0.269	-0.614	0.532

This indicates that faculty training plays a very pivotal role in the adoption of lean education in academia. The level of awareness (3.63) on Lean in construction was found to be above average. Faculties are skeptic about the Lean in academia. The Curriculum Framework (3.78) supporting Lean was also not favorable to a large extent. Framing a curriculum for lean construction education requires constant updation and inclusion of new techniques into the syllabus. The values of Skewness and Kurtosis was within the prescribed limits indicating that the data are normal for further statistical analysis.

D. CORRELATION ANALYSIS

The aim of Correlation Analysis is to identify the relationship among various Lean factors. The value of correlation is expressed using Pearson's Correlation Coefficient (R). Table 6 shows that Technical Skill / Training and Awareness are positively correlated (R=0.271) and showed significant relationship at 5%. Similarly, Cost Expenditure is positively correlated with Awareness (R = 0.418) and the level of correlation was significant at 1% level. Also you can find thatCost Expenditure andLean Culture (R= 0.308) are correlated with each other, again with 1% level of significance. Employees Attitude is positively correlated with Awareness (R = 0.358) and the level of correlation was significant at 1% level. In addition you can even find that Cost Expenditure is positively related with Technical Skill/ Training (R= 0.272) and the level of correlation was significant at 5% level. The study revealed that the factors like Employees Attitude are not correlated with Technical Skill / Training, Cost Expenditure and Lean Culture. Lean Culture is not correlated with Awareness and Technical Skill / Training.

Table 7 shows the correlation among the Lean factors based on the responses of academia sample of the study. There is a significant positive correlation between the factors like Teaching methodology and Awareness (R=0.259), Curriculum framework and Awareness (R=0.356), Curriculum framework and Teaching methodology (R=0.267).

Table 6: **Correlation (Industry)**

Factors	Awareness	Technical Skill / Training	Cost Expenditure	Lean Culture	Employees Attitude
Awareness	1				
Technical Skill / Training	0.271*	1			
Cost Expenditure	0.418**	0.272*	1		
Lean Culture	0.199	0.142	0.308**	1	
Employees Attitude	0.358**	0.072	0.119	0.163	1

Table 7: Correlation (Academia)

Factors	Awareness	Faculty training programmes	Teaching methodology	Curriculum framework
Awareness	1			
Faculty training programmes	0.150	1		
Teaching methodology	0.259*	0.098	1	
Curriculum framework	0.356**	0.058	0.267*	1

* Correlation is significant at 0.05 level (2-tailed) &** Correlation is significant at 0.01 level (2- tailed).

E. RII Ranking

The relative importance index for the factors pertaining to industry is given in table 8.

Table 8: **RII Values (Industry)**

Factors	**RII Value**	**Rank**
Awareness	0.77	3
Technical Skill / Training	0.87	1
Cost Expenditure	0.82	2
Lean Culture	0.752	4
Employees Attitude	0.724	5

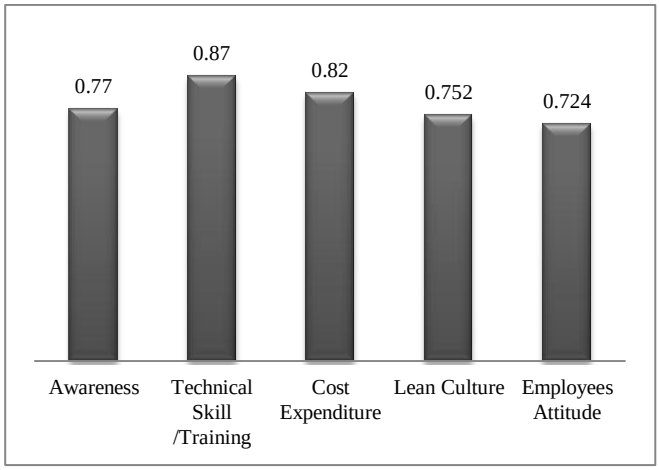

Fig. 2: RII Graphical Representation (Industry)

The relative importance index for the factors pertaining to academia is given in Table 9.

Table 9: **RII Values (Academia)**

Factors	**RII Value**	**Rank**
Awareness	0.726	4
Faculty trainingprogrammes	0.792	1
Teaching Methodology	0.76	2
Curriculumframework	0.756	3

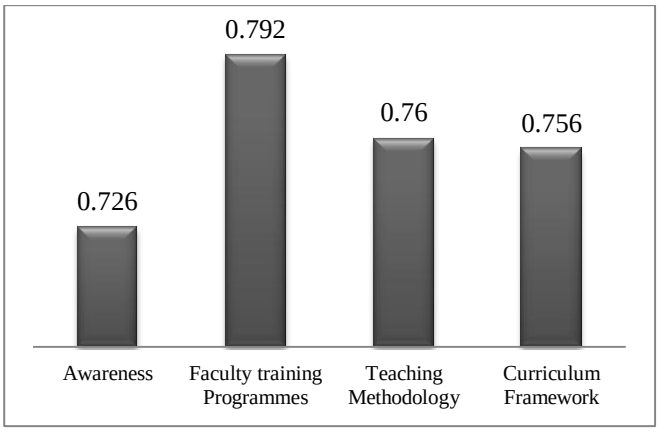

Fig. 3: RII Graphical Representation (Academia)

IV. CONCLUSION

The aim of the project was identifying and analyzing the factors impacting Lean adoption in the industry and academia. The study explored the current level of Lean adoption in the industry as well as the academia. The study was conducted with selected construction companies and academic institutions in South India.

As an outcome of extensive review of literature, five factors (Awareness, Technical Skill / Training, Cost Expenditure, Lean Culture and Employees Attitude) were identified for measuring the evolution of Lean concepts in construction industry and four factors (Awareness, Faculty Training Programmes, Teaching Methodology, and Curriculum Framework) were identified for measuring the evolution of Lean concepts for construction in academia. Based on descriptive statistics, correlation analysis and RII the following conclusions can be drawn:

- Training Programmes were found to be the most important factor influencing the adoption of lean in industry and academia, therefore proper training for faculties and employees should be given, only then they will be familiar with the lean concepts and techniques.
- The implementation of lean accompanies a lot of initial cost expenditures which makes it the second most influential factor in the adoption of lean in case of industry. Therefore initial investment should be made on those resources which can exploit lean concepts and prove profitable in the long run.
- The study concluded that awareness is ranked as the third most important factor which affects the adoption of lean on construction site. Though people are having a basic idea about lean, many lack an in-depth knowledge and proficiency which can be overcome by indoctrination.
- In case of academia, teaching methodology was found to be the most impacting factor after faculty training programmes. Thus, teaching lean in academia requires the shift from conventional methods of lectures to new methods like simulation games, site visits and group discussions to blend theory with action.
- Formulation of a well updated curriculum is also found to be an important factor influencing lean construction education in academia. In-order to teach lean to students the curriculum should be revised frequently since continuous improvement is the fundamental criteria of lean management.

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