Students' perception of strategies for effective lean knowledge in future Nigerian construction industry

Adefemi Aka
Department of Building, Federal University of Technology Minna, Minna, Nigeria

Abubakar Danladi Isah
Department of Architecture, Federal University of Technology Minna, Minna, Nigeria

Olusegun Idris Salisu
Department of Building Technology, Federal College of Education Technical Akoka, Lagos, Nigeria, and

Abdulkabir Opeyemi Bello
Department of Building, Federal University of Technology Minna, Minna, Nigeria

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Abstract

Purpose – Waste has been a major challenge in the construction industry. Lean concepts have been adopted in developed nations to overcome waste. However, developing countries are still faced with the challenge due to a lack of strategies for effective lean knowledge by construction practitioners. The purpose of this research is to identify the strategies for lean knowledge in the future Nigerian construction industry.

Design/methodology/approach – This was achieved through a case study of a Nigerian university. Assignments and questionnaires were the two instruments used for data collection in the study. Content analysis was adopted to analyse the data obtained from the assignments, while statistical tools such as correlation and ANOVA analysis were used to analyse the questionnaire data.

Findings – The findings of the study showed that the introduction of lean theory into students' academic curriculum, lean practical classes and collaboration between universities, industry and lean construction institutes are some of the critical strategies for adequate lean knowledge in the future Nigerian construction industry.

Research limitations/implications – The study is case-based and focused on a single university. The study did not also put clients' level of lean knowledge as well as future required acquaintance into consideration.

Practical implications – This study is important as it will enable students to have an adequate understanding of the concept of lean construction right from a higher institution level. This study will enable students to put the knowledge into practice in the construction industry, hence eliminating waste or NVAAs in future construction projects.

Originality/value – The findings of the study could enhance concerted efforts by universities, lean construction institutes and the construction industry towards an intentional and systematic delivery of lean knowledge that will reduce waste in future Nigerian construction projects. Further studies should be carried out to identify the success factors required by clients for effective lean knowledge in construction projects.

Keywords Strategies, Lean, Knowledge, Construction industry, University, Students

Paper type Research paper

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1. Introduction

The construction industry plays a vital role in the economic growth and development of any nation through several activities (Oladinrin *et al.*, 2012; Afroz, 2018). Among these activities are shelter and infrastructure development (Tanko *et al.*, 2017; Manu *et al.*, 2020; Ruya *et al.*, 2018; Osuizugbo and Ojelabi, 2020). This implies that the relevance of the construction industry to the economic condition of many nations across the globe cannot be over-emphasized.

Despite the benefits of the construction industry advocated above, the industry is characterized by a high incidence of waste or non-value-adding activities (NVAAs) in the lean term (Koskela, 1992; Womack and Jones, 2003; Koskela *et al.*, 2013; Yusuf *et al.*, 2016). Nwanya and Oko (2019) affirmed that the construction industry, specifically in the developing nations operates in traditional mass production principles and methods that constitute waste or NVAAs in construction projects. This has led to delay, cost overrun and inefficiency that indicates a research gap on how to curtail waste in the construction industry. It is imperative to note that lean tools and techniques such as value stream mapping, 5 Whys, Kanban (pull systems), A3 problem-solving report, Kaizen, daily huddle meetings, look-ahead schedule, quality assurance, total quality control and just-in-time can be used to reduce waste in construction projects (Koskela, 1992; Koskenvesa *et al.*, 2010; Forbes and Ahmed, 2011).

Despite the implementation benefits of lean tools and techniques in many developed countries', extant studies revealed that the construction industry, specifically in developing nations, is faced with the challenge of waste due to lack of or inadequate knowledge of lean concepts by projects managers in such countries (Hines *et al.*, 2004; Boyle and Scherrer-Rathje, 2009; Goodyer *et al.*, 2011; Schröders and Cruz-Machado, 2015; Pearce and Pons, 2017; Pearcea *et al.*, 2018; Nwanya and Oko, 2019). Pearcea *et al.* (2018) pointed out that managers' lack of knowledge is the root cause of the factors responsible for the failure of lean implementations in the construction industry. In other words, the adoption of lean construction for waste elimination in developing countries such as Nigeria is still at the infancy stage (Goodyer *et al.*, 2011; Schröders and Cruz-Machado, 2015; Pearce and Pons, 2017; Nwanya and Oko, 2019). Therefore, further study is required to examine the strategies that can promote lean thinking/transformations or knowledge for effective lean practice in the future Nigerian construction industry.

Furthermore, most of the studies carried out by previous researchers on lean implementation strategies in construction projects are focused on professionals/expert opinions on the subject matter. Limited studies have considered students' learning perspectives specifically in universities. Traditionally, the purposes of higher institutions are to teach and conduct research and prepare the workforce for a nation (Comm and Mathaisel, 2005). According to Opoku and Egbu (2018), university students constitute a critical mass of stakeholders in the construction industry. They play a strategic role in the industry's quest to attain the required knowledge for the progress of the industry. Therefore, the assumption put forward in this study is that students are the future decision makers (managers and the like) who will be responsible for implementing lean in the future construction industry. Consequently, adequate lean knowledge acquired in school could lead to effective practice of lean in future construction industry. Hence, students' perspectives on the intentional acquisition of factors responsible for low lean knowledge among practitioners and the underlying strategies that can be used to increase lean knowledge in the future Nigerian construction industry need to be further investigated.

As the students in engineering and built environments in higher institutions in Nigeria are being prepared to take over the future construction industry, this study provides

insights into the students' understanding of the concept of lean construction right from the higher institution level. This is crucial in proliferating lean knowledge among the current students. Hence, excluding the industry from the need to train young school leavers on the subject matter before employment.

2. Literature review

2.1 An overview of lean knowledge in the developing nations' construction industry

The literature revealed that waste could be eliminated in the construction process through different lean techniques and tools (Hicks, 2007; Holweg, 2007; Arayici *et al.*, 2011; Ko and Chen, 2012; Ko and Tsai, 2013; Ko and Chung, 2014; Aka *et al.*, 2019a). However, in developing nations, including Nigeria, construction industry practitioners have low knowledge of lean practice (Pearce and Pons, 2017; Ismail and Yusof, 2016; Pearcea *et al.*, 2018). This has made waste (physical and non-physical) to persist in construction projects in such countries, leading to poor project performance. For effective project performance, physical and non-physical waste need to be eradicated through adequate lean knowledge by construction professionals. Hence, the need for this study.

2.2 Barriers to effective lean knowledge in the developing nations' construction industry

There are several studies on barriers or factors that could impede the successful implementation of lean concepts in developing nations' construction projects. However, when this study was conducted, there seemed to be scarce literature on barriers to adequate lean knowledge in the construction industry. Therefore, in this study, the barriers to lean implementation in construction projects were reviewed and served as parts of the construct for barriers to lean knowledge in the questionnaire used for data collection. Typical form of factors that can hinder lean implementation in developing nations construction projects are lack of proper planning and control, lack of teamwork, poor project management, lack of technical capabilities, lack of financial resources, poor communication between parties, lack of education, lack of or inadequate government support, managerial/technical issues, lack of top management commitment, cultural diversity/human attitudinal issues, resistance to change, lack of clients interest and lack of process-based performance measurement systems (Senaratne and Wijesiri, 2008; Alinaitw, 2009; Gao and Low, 2014; Abduh and Roza, 2006; Olatunji, 2008; Sarhan and Fox, 2013).

2.3 Frameworks for lean knowledge in the developing nations construction industry

Many organizations in developing countries such as China and India were interested in transforming their traditional systems to be more productive by adopting lean (Panizzolo *et al.*, 2012). However, the adoption of lean in developing countries is not yet comparable to developed ones due to several challenges including inadequate knowledge or awareness of lean concepts (Zargun and Al-Ashaab, 2014). Therefore, it is rare to find a sustainable lean knowledge/adoption framework in a developing country in the literature (Andejany, 2017). Therefore, strategies for lean knowledge in the future Nigerian construction industry can be proposed through students' perspectives.

3. Research methodology

3.1 The case study approach

The interpretivist research approach that enabled the researchers to base the study on a case study of a Nigerian university was adopted. Case-study as a research approach has been used to obtain primary data in several lean research (Holweg, 2007; Jasti and Kodali, 2015;

Aka *et al.*, 2019b). The study by Bryman (2004) revealed that the interpretivist originates from phenomenology study, and it has to do with the study of how a group of people make sense of the world around them through interaction. This implies that the interpretivist belief that knowledge is socially constructed, subjective and influenced by culture and social interactions in a group of people. Therefore, the study used post-graduate students (masters and PhD) in architecture, building and quantity surveying departments in a Nigerian University as interactive groups of people for the primary source of data collection.

Civil engineering, architecture, building and quantity surveying students were selected because they were the only students offering core construction programmes at the selected university. Only students' that have worked in different construction firms for not less than five years before the commencement of their post-graduate programme were selected for the study. These categories of students were selected as the researchers perceived that they might have been involved in the execution of different projects across the country and might have the requisite knowledge to answer the set research questions. This sampling strategy reduced the number of the study participants from 103 to 38, comprising of 10 from civil engineering, seven from quantity surveying, nine from building and 12 from architecture, respectively.

At the start of the study, the consent of all the participants was first obtained through the heads of the four departments, heads of the various faculties and the dean of post-graduate study at large. Thereafter, the participants were informed of the aim of the research. A three-week lean thinking workshop training was also organized for the participants of the study. In the training, the participants had the opportunity to understand what lean thinking entails. The principles, methods, techniques, tools, benefits, implementation strategies and challenges involved in its implementation were all explained to the participants of the study in the lean workshop training. The participants were also informed of the tool (assignments/exercises) that will be adopted for illustration during the study. They were also told of the duration and number of assignments/exercises to anticipate in the study. Scientific research can be conducted through students' assignments/exercises (see Jahan and Goggett, 2015b). Smith (2015) and Jahan and Doggett (2015a) also adopted students' perceptions to investigate how lean principles can be made applicable at the university level.

The selected students were informed that in some of the assignments/exercises, there might be a need for them to visit the firms where they served before the start of their post-graduate programme for updated practical knowledge. After the training, the participants were grouped into four according to their departments with an agreed date of commencement of the main study. On each agreed day, a particular exercise based on the objectives of the study would be given to all the groups. The exercise would be carried out by each group and submitted as a report through the group leader. Thereafter, each group leader would present the report to the house based on the agreed day. After the presentation, questions would be raised from other groups and the researchers for clarification and agreement by everyone present. The outcomes of each exercise or assignment from each group were further compared and summarized into themes by the researchers.

For further analysis and validity of the data obtained in the case study, the themes that were obtained in all the assignments were used to prepare a questionnaire for a survey exercise that formed the last phase of the study. In all, the case study phase took approximately three months in duration.

3.2 The questionnaire strand

In the last phase of the study, a questionnaire survey was conducted to seek the respondents' agreement on a range of factors predetermined from the post-graduate

students' perspectives. The questionnaire survey was also used for further data analysis in the study. Therefore, the design of the questionnaire was strictly based on the information obtained in the existing literature on the subject matter and the case study that was first conducted. The questionnaire consisted of close-ended questions. It was administered directly to construction professionals working in registered firms located in Abuja, the capital city of Nigeria. A purposive technique was adopted to obtain the population's accurate representation. This implies that out of 188 registered construction firms discovered during the study, emphasis was placed on the firms that have been existing for more than 10 years; their employees' have been involved in different projects ranging from small to large and were willing to participate in the study. These conditions were used to reduce the total number of study firms to 26. It is imperative to note that the 26 numbers are only from medium and large construction firms.

Therefore, the designed questionnaire was administered directly to 187 construction professionals (civil engineers, architects, builders and quantity surveyors) who were randomly selected from the study firms. However, only 125 were correctly filled and returned by the respondents, which represents a 66.84% response rate (Table 1).

The questionnaire distributed was mainly in two parts. The first part was to find out the level of the respondents' knowledge in term of lean concepts. This was necessary so as to be sure that they were qualified to validate the outcomes or opinions of the post-graduate students in the case study section. Therefore, the questions in this part centred on the participants' awareness, importance and interest in lean construction (Tunji-Olayeni *et al.*, 2020 for a similar reason). The questions were presented on a five-point Likert scale ranging from very aware/important/interested (5) to not at all aware/important/interested (1). The second part of the questionnaire focused attention on the validity of the outcomes of the case study. In this section, the respondents were required to also indicate on a five-point Likert scale their agreement on all the information obtained in the case study phase. In this part, the five-point Likert scale ranges from 1= strongly disagree/very low to 5 = strongly agree/very high (Doloi *et al.*, 2012; Gravetter and Wallnau, 2008 for similar scales). The academic qualifications of all the participants of the survey study range from ND to master's degree.

The data obtained in the survey exercise were analysed through descriptive and inferential statistics. To be precise, the analysis consists of four distinct steps, which include the following:

- Cronbach's alpha (α), skewness (S) and kurtosis (K) tests, which were used to determine the reliability of the outcome of the five-point Likert scale (Curran *et al.*, 1996; Gliem and Gliem, 2003). In the analysis, variables with a mean item score (MIS) of 3.5 and above were considered very significant. While those that are between 3.0 and 3.49 are rated significant. Whilst, those that are less than 3.0 are classified as less significant (Sakaram and Bougie, 2010).

Respondents	No. of questionnaires distributed	No. of questionnaires returned and analysed
Civil engineers	37	26
Architects	61	41
Builders	57	39
Quantity surveyors	32	19
Total	187	125

Source: Created by author

Table 1. Details of the questionnaires distributed and returned in the survey study

- Pearson correlation analysis was used to further validate the information obtained on the factors responsible for low lean knowledge in the Nigerian construction industry.
- While ANOVA analysis was used to determine the relationships in the established strategies (teaching plans) and future trends on lean knowledge in Nigerian construction industry (Digital Bridge Institute (DBI) 2018).

4. Presentation of findings

4.1 The case study phase

4.1.1 Barrier to adequate lean knowledge in Nigerian construction industry. Premised on one of the assignments given to the students, the reports from the four groups revealed that inadequate involvement of students in the built environment international conferences, more attention on theoretical knowledge than practical at undergraduate and post-graduate levels, inadequate time for students' industrial experience, non-integration of lean theory in students' academic curriculum and lack of collaboration between universities, construction industry, international groups for lean construction/lean construction institute are the underlying factors responsible for low lean knowledge in the current Nigerian construction industry. Other factors as pointed out by one of the groups, can be summarized as follows:

- Lack of clients interest/demand for lean projects: most of the clients in the study context do not understand what a lean project is i.e. its application and benefits in construction projects. This often discourages the professionals in such an environment from going for lean training/workshops for the acquisition of lean knowledge.
- Excessive workloads/work pressure that employees cannot cope with: the professionals in the study context are always overwhelmed with different construction activities due to a shortage of professionals. The few available ones put in longer hours than ever before. This hinders them from having time for lean workshop training throughout the year.
- *Lack of orderliness among workers*: On construction sites, there is an untidiness or disorder among the workers, which often leads to fatigue that could limit them from further training after daily activities.
- *Poor working environment/relationship among the construction team*: i.e. bad communication or relationship, unethical or dishonest behaviour, punishing procedures or policies between the junior workers and superior leaders characterize could make the superior leaders not allow the junior workers go for further training that can give room for effective lean knowledge.
- *Lack of competition between the local and international construction industry*: there seems to be no competition between the indigenous and foreign construction industries. This hinders the indigenous workers from aspiring for innovative knowledge such as lean thinking.
- Lack of sense of self-efficacy: this is a motivational technique that is seriously lacking in the case study firms. The literature shows that the involvement of employees in decision-making process enhances employees to be self-efficacy, which, in turn, motivate them to get involved in all form of additional knowledge that can contribute to the organization's performance (Greenfield, 2004; Wong, 2007; Horsford, 2013).

4.1.2 Strategies for adequate lean knowledge in Nigerian future construction industry. The last assignment was carried out by the students so as to propose strategies that can be used for effective lean knowledge in the Nigerian future construction industry. Table 2 summarizes the information obtained in this section.

4.2 The questionnaire strand

4.2.1 The level of the respondents' knowledge in lean concepts. The level of the respondents' knowledge in lean concepts was assessed through three perspectives, which are awareness, importance and participants' interest in lean construction (see Tunji-Olayeni *et al.*, 2020 for a

Strategies	Description
Introduction of lean theory to students' academic curriculum	Civil engineering, architecture, building and quantity Surveying departments should incorporate lean theory into students' curriculum, particularly at early study stage
Introduction of lean practical classes	Just like building construction, strength of materials and Concrete Technology courses that have practical classes for further students' understanding, practical classes where the application of lean tools and techniques can further be demonstrated to the students should be introduced in the four departments. In each practical class, students should be assessed, scored and graded. Attendance should also be made compulsory for all the students
Introduction of chartered lean civil engineer, architect/builder/quantity surveyor	Just like COREL, registered architect, quantity surveyor, builder (CORBON), fresh graduates from aforementioned departments should be mandated to write and pass exams that will qualify them as chartered lean engineers/architect and the likes. They can start as student member just like other professional bodies like NIOB. Lean Construction Institute (LCI) or International Groups for Lean Construction (IGLC) can be saddled with such responsibility
Collaboration between universities/ students, LCI and the IGLC	The IGLC and LCI should carry universities/students along in their annual conferences by encouraging students to fully participate
Adequate collaboration between construction industry and university in term of lean research	Adequate collaboration between construction industry and university in research that are related to waste or NVAAs in projects. This may enable the industry to make use of the findings from the research carried out by university students
Regular seminar or workshop trainings on lean practice and awareness should be organized between construction industry and university students	The main objective of the seminar or workshop trainings should be sentenced on lean knowledge in future construction industry. Such trainings can be effective or frequent through adequate government supports
Extension of SIWES periods from six months to one year so as to improve students practical knowledge	For effective lean knowledge among the students, internship (SIWES) should be extended from six months to a year programme. This will enable students' to effectively put into practice their lean knowledge which they have acquired in the school. This can also be made possible or effective through government supports

Source: Created by author

Table 2. Strategies for effective lean knowledge in Nigerian future construction industry

similar reason). The data obtained from the respondents' in the various firms was analysed separately so as to know if all the respondents' were qualified to answer the subsequent section of the questionnaire. The α values obtained for all the respondents (0.967: excellent) show that the data obtained is reliable and can be accepted for the study (Table 3).

Similarly, skewness (S) and kurtosis (K) values in Table 3 revealed that the data obtained in this section of the study is accurate. Curran *et al.* (1996) opined that data is considered excellent when S ranges are fewer than 2 and the K is fewer than 7, which were applicable to the analysed data in the study. The MIS of all the quantity surveyors in the study firms on awareness, importance and interest in lean concepts implies that not all the quantity surveyors in the selected firms are knowledgeable or familiar with lean concepts. However, the results further show that other professionals are knowledgeable or familiar with lean concepts in the construction industry. This may be due to the institutions where they graduated from or their experience in the construction industry. Based on the poor responses of the Quantity Surveyors in the selected firms, the questionnaires that were returned back from them were removed and discarded.

4.2.2 Respondents agreement on factors responsible for inadequate lean knowledge in Nigerian construction industry. The factors responsible for lack of lean knowledge by construction practitioners present in this section amplify the need to proffer for strategies that can be adopted for adequate lean knowledge in the study context and in the global construction industry (Table 4).

Based on the information abridged in Table 4, it can be emphasized that the respondents of the survey exercise strongly believe that variables such as non-integration of lean theory in students' academic curriculum, lack of collaboration between the construction industry, International Groups for Lean Construction/Lean Construction Institute (IGLC/LCI), lack of technical capabilities, lack of financial resources by construction firms and more attention on theoretical knowledge than practical at undergraduate and post-graduate levels (MIS above 3.5) are the major factors responsible for low lean knowledge in the current Nigerian construction industry. While factors such as inadequate involvement of students in international conferences, lack of clients' interest or demand for lean projects, managerial/technical issues, lack of top management commitment and lack of sense of self-efficacy (motivation) are the significant factors. Other variables such as lack of competition between the local and international construction industry, lack of process-based performance measurement systems, excessive workloads/work pressure that employees cannot cope with, lack of competition between the local and international construction industry and lack of orderliness among workers were rated low by the respondents. This implies that such variables are not significant factors for low lean knowledge in the current Nigerian construction industry. The views of the respondents' correspond with the findings of the case study that was first conducted. Based on the factors responsible for low lean knowledge in the Nigerian construction industry, studies on

Table 3.
Respondents' knowledge in lean concepts in the construction industry

	Architects			Builders			Quantity surveyors			Civil engineers		
Variables	MIS	S	K	MIS	S	K	MIS	S	K			
Awareness of lean concepts	3.0	−1.1	−0.5	3.0	1.3	1.2	2.4	0.7	0.3	3.1	0.8	1.3
Importance of lean concepts	3.3	1.2	1.1	3.2	−0.9	−0.4	1.6	0.1	0.5	3.1	1.1	0.6
Interest in lean concepts	3.1	0.7	0.3	3.3	−1.4	−1.7	2.8	−1.5	−0.3	3.2	0.4	0.1

Source: Created by author

Responsible factors	MIS	S	K	Rank
Inadequate involvement of students in international conferences (RF1)	3.84	1.4	0.2	7th
More attention on theoretical knowledge than practical at undergraduate and post-graduate levels (RF2)	4.62	−1.1	−1.3	3rd
Inadequate time for students' industrial experience (RF3)	4.44	0.7	0.2	4th
Non-integration of lean theory in students' academic curriculum (RF4)	4.88	0.5	0.4	1st
Lack of collaboration between universities, construction industry IGLC and LCI (RF5)	4.81	−1.1	−1.2	2nd
Lack of clients interest or demand for lean projects (RF6)	4.37	0.5	0.3	5th
Excessive workloads/work pressure that employees cannot cope with (RF7)	2.57	1.4	1.3	19th
Lack of orderliness among workers (RF8)	2.41	−0.3	−0.1	20th
Poor working environment (RF9)	3.82	1.3	1.5	8th
Poor working relationship among the construction team (RF10)	4.18	0.4	0.7	6th
Lack of competition between the local and international construction industry (RF11)	2.47	−1.7	−1.4	14th
Lack of sense of self-efficacy (motivation) (RF12)	3.47	0.6	0.3	11th
Lack of proper planning and control by firms managers (RF13)	3.45	0.5	0.1	12th
Inadequate teamwork among construction professionals (RF 14)	2.27	−1.1	−1.3	23rd
Poor projects management (RF 15)	2.25	−1.5	−1.2	24th
Lack of technical capabilities (RF 14)	3.62	0.7	0.3	9th
Lack of financial resources by construction firms (RF 15)	3.48	0.8	0.4	10th
Poor communication between the parties involved in projects execution (RF 16)	3.43	1.3	1.5	13th
Inadequate construction skills (RF 17)	3.43	1.4	0.2	13th
Lack of or inadequate government support (RF 18)	2.31	1.1	1.3	22nd
Managerial/technical issues (RF 19)	3.41	1.5	1.1	15th
Lack of top management commitment (RF 21)	3.37	0.2	0.1	16th
Cultural diversity/human attitudinal issues (RF 22)	2.33	−1.1	−1.3	21st
Resistance to change (RF 23)	3.35	−0.5	−0.3	17th
Lack of clients interest (RF 24)	3.21	1.1	1.4	18th
Lack of process-based performance measurement systems (RF 25)	2.11	1.2	1.6	25th

Note: The α values obtained = 0.917 (Excellent)
Source: Created by author

Table 4. Reasons for inadequate lean knowledge in Nigerian construction industry

strategies that can be adopted for effective lean knowledge and practice by "all and sundry" in the Nigerian construction industry are required. These are needed as such studies will enable construction practitioners to eliminate all forms of waste in their practices.

4.2.3 Pearson correlation analysis for factors responsible for low lean knowledge in Nigerian construction industry. Premised on MIS values in Table 4, Pearson correlation analysis was carried out on the very significant variables (MIS with 3.5 and above). The outcomes of the analysis are presented in Table 5.

In the correlation analysis, the nine identified factors served as the independent variables, whereas low lean knowledge was the dependent variable (DBI, 2018). The Pearson correlation coefficient results in Table 5 show that all the identified factors are above 0.5 at a two-tailed significant level. Therefore, there is a significant relationship between all the nine factors and low lean knowledge in the Nigerian construction industry. Hence, it can be emphasized that the very significant variables have noteworthy effects on the low level of lean knowledge in the current Nigerian construction industry.

4.2.4 Respondents agreement on strategies for adequate lean knowledge in Nigerian future construction industry. Table 6 indicates the respondents' agreement on the strategies that can be used for effective lean knowledge in the future Nigerian construction industry.

Table 5.
Pearson correlation analysis table

RF	RF1	RF2	RF3	RF4	RF5	RF6	RF7	RF8	RF9	Low lean knowledge
RF1	1.000									
Pearson's correlation Significance (two-tailed)	0.000									
N	106									
RF2	0.812	1.000								
Pearson's correlation Significance (two-tailed)	0.000	0.000								
N	106	106								
RF3	0.863	0.914	1.000							
Pearson's correlation Significance (two-tailed)	0.000	0.000	0.000							
N	106	106	106							
RF4	0.712	0.719	0.832	1.000						
Pearson's correlation Significance (two-tailed)	0.000	0.000	0.000	0.000						
N	106	106	106	106						
RF5	0.723	0.641	0.772	0.845	1.000					
Pearson's correlation Significance (two-tailed) 0.000	0.000	0.000	0.000	0.000						
N	106	106	106	106	106					
RF6	0.739	0.741	0.673	0.623	0.641	1.000				
Pearson's correlation Significance (two-tailed)	0.000	0.000	0.000	0.000	0.000	0.000				
N	106	106	106	106	106	106				
RF7	0.678	0.716	0.673	0.611	0.651	0.653	1.000			
Pearson's correlation Significance (two-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000			
N	106	106	106	106	106	106	106			
RF8	0.567	0.612	0.531	0.634	0.511	0.627	0.617	1.000		
Pearson's correlation Significance (two-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		
N	106	106	106	106	106	106	106	106		
RF9	0.551	0.536	0.571	0.567	0.511	0.568	0.501	0.541	1.000	
Pearson's correlation Significance (two-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
N	106	106	106	106	106	106	106	106	106	
Low lean knowledge	0.913	0.904	0.871	0.862	0.822	0.765	0.721	0.673	0.601	1.000
Pearson's correlation Significance (two-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
N	106	106	106	106	106	106	106	106	106	106

Source: Created by author

Strategies	MIS	S	K	Rank
Introduction of lean theory into students' academic curriculum (S1)	4.71	0.5	0.4	1st
Practical classes where the application of lean tools and techniques can further be demonstrated through different methods (S2)	4.63	1.4	1.3	2st
In each lean practical class, students should be assessed, scored and graded so as to take the class very serious. Attendance should also be made compulsory for all the students (S3)	4.57	−0.2	−0.1	3rd
Fresh graduates should be mandated to write and pass exams that will qualify them as Chartered Lean architects/builders/quantity surveyors (S4)	4.52	1.3	1.3	4th
Similar to other professionals bodies such as NIOB, lean institute students member should be introduced to undergraduate students (S5)	4.50	0.2	0.7	5th
IGLC and LCI should carry students along in their annual conferences by encouraging students to participate by subsidizing conference fee for the students or make grants to be available for the outstanding students (S6)	4.45	−1.5	−1.4	6th
Adequate collaboration between construction industry and university in term of lean research (S7)	4.41	0.7	0.3	7th
Time to time seminar or work shop on lean practice and awareness should be organized between construction industry/IGLC/LCI and university students (S8)	4.35	0.2	0.4	8th
SIWES periods should be extended from six months to one year so that students will have adequate time to do their SIWES in lean practice construction firms in abroad (S9)	3.82	0.6	0.3	9th
SIWES credits units should be increased from 12 to 48, which may enable the students to take the exercise very serious (S10)	3.56	−1.6	−1.2	10th
SIWES grants should be given to students to enable them do their proposed one-year SIWES in lean practice firms located in UK or USA (S11)	3.21	1.3	1.2	11th

Note: The α values obtained = 0.911 (excellent)
Source: Created by author

Table 6. Strategies for effective lean knowledge in future Nigerian construction industry

The ranking in the table suggests that eight out of the 11 proposed strategies are highly significant factors. While three are significant factors. To further validate the agreement of the respondents on the effect of the strategies on lean knowledge in the future Nigerian construction industry, an ANOVA analysis was conducted (Table 7).

In the analysis, 11 strategies (highly significant and significant) served as independent variables, whereas adequate lean knowledge in future Nigerian construction industry served as dependent variable. The ANOVA analysis results in Table 7 indicate that the F-value is 6.775 at 0.000 (p-value) two-tailed significant level. This implies that there is a significant relationship between the discovered strategies and effective lean knowledge in future Nigerian construction industry (DBI, 2018).

	Model	Sum of squares	Df	Mean square	F	Sig.
1	Regression	0.425	1	0.416	6.775	0.000
	Residual	1.347	10	0.692		
	Total	1.772	11			

Source: Created by author

Table 7. ANOVA analysis table

4.3 Discussion on the identified strategies

It can be emphasized that there is a statistically significant relationship between the established strategies in this study and effective lean knowledge in future Nigerian construction industry. This confers that if these strategies are effectively implemented, to practice lean in future Nigerian construction industry will not be difficult. Studies by Womack (2007) and Hallam *et al.* (2010) revealed that implementing lean in a piecemeal manner or focusing on the technical execution without recognition of the human factors will make the practice to be practically impossible. Therefore, recognizing students who will occupy the future construction industry based on the established strategies will enhance lean knowledge among future construction stakeholders and make the implementation process a work over. This is feasible as the proposed teaching plans could promote a deeper understanding of lean thinking in term of its waste elimination benefits among the students, which are the future construction managers.

In addition, the literature indicates that lack of lean knowledge by project managers is the overriding factor for the failure of lean implementations. Furthermore, Emiliani and Stec (2005) contended that a robust implementation of lean requires an enterprise-wide management system. Which can be made possible through effective collaborative learning (Liker, 2004; Hines and Lethbridge, 2008), the concepts of double-loop learning (Hu *et al.*, 2015), the learning organization (Darlington and Jones, 2010) and continuous learning (Vlachos, 2015). Therefore, continuous acquisition of lean knowledge by higher institutions students from 100 level will transform the future construction industry in terms of lean practice/implementation. Consequently, the assumption or hypothesis that adequate lean knowledge acquired by university students while in school could lead to the effective practice of lean in future Nigerian construction industry should be accepted in this study. Based on the findings of this study, strategies for effective lean knowledge in future Nigerian construction industry is developed and presented in Figure 1.

The information in Figure 1 is well and self-explanatory. According to the figure, lean knowledge strategies will be applied immediately after the students resume 100 level and will continue until the graduation period. It is anticipated that after passing through the various academic levels and conferences/workshop training, the students will have acquired the necessary lean knowledge which will enhance lean practice in the construction industry.

5. Implication/limitation of the study

This study is important as it will enable students to have an adequate understanding of the concept of lean construction right from a higher institution level. This will enable them to put the knowledge into practice in the construction industry, hence eliminating waste or NVAAs in future construction projects. In other words, the findings of the study could enhance concerted efforts by the universities, construction industry, IGLC and LCI towards an intentional and systematic delivery of lean knowledge that will reduce waste in future Nigerian construction industry. The study is a case-based and focused on a single university. Expanding the study across other regions and universities will consolidate the base viewpoint with a broader perspective on the subject matter. The study did not also put clients' level of lean knowledge as well as future required acquaintance into consideration. Therefore, further study should be conducted by future researchers on strategies for effective lean knowledge by prospective construction clients'.

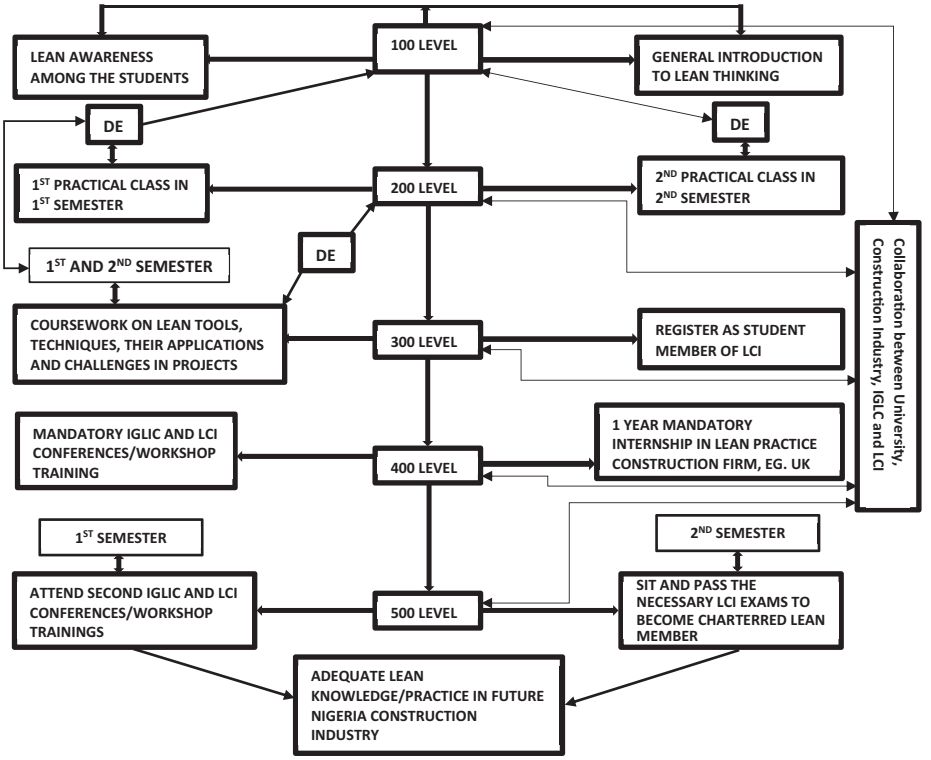

Figure 1.
Students learning plans for effective lean knowledge in future Nigerian construction industry

Note: DE = direct entry students
Source: Created by author

6. Conclusion

By and large, the continuous adoption of manual construction skills rather than adopt the use of machinery and technology mainly accounts for the reason why wastes is a common occurrence in the current Nigerian construction industry. In other words, tangible and intangible wastes exist in the current Nigerian construction projects. These are largely attributed to the lack of lean construction knowledge and application by construction firms.

Contemporary lean construction, which has paved progress for many of the construction firms' across the globe, specifically the developed world, would be an improvement over the traditional method with its accompanying problem of waste or NVAAs in project performance. Hence, lean thinking is believed to be a solution to many of the waste or NVAAs encountered in construction projects. However, the adoption of lean concepts in Nigeria's construction industry has been very slow due to inadequate lean knowledge by construction practitioners. This implies that lean concepts have not been maximally used by Nigerian construction firms. To make use of lean concepts in the Nigerian construction industry will entail a full understanding of lean principles, techniques and tools through certain underlying strategies.

Invariably, the need to inculcate lean knowledge in the university curriculum was established through the exploration of students' experience with waste, the impact of the

absence of lean knowledge and their perception of lean knowledge in the curriculum. Most importantly, the study established the critical strategies of learning lean knowledge, which was recommended for adoption in university curriculum and extensive collaborations between universities, industry and lean institutes (IGLC and LCI) to bridge the existing gap and also to equip future managers and stakeholders in Nigerian construction industry.

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Corresponding author

Adefemi Aka can be contacted at: aka.femi@futminna.edu.ng