Journal of Construction Project management and Innovation

Volume 7 Number 1 June, 2017

ISSN 2223-7852

ABOUT JCPMI

The **Journal of Construction Project Management and Innovation** is published bi-annually (twice per year) through the Sustainable Human Settlement and Construction Research Centre (SHSCRC) of the University of Johannesburg, by Sabinet Online - SA ePublications.

Journal of Construction Project Management and Innovation is an open access journal that publish all sorts of researches on Construction project management; Project management; Design and construction management processes; Housing and infrastructure development; Stakeholder management; Project planning and project impact assessments; Design and implementation of labour-intensive projects; Procurement management; Management of construction companies; Industry development; Knowledge management in construction; Empowerment of women; Innovation; Project financing; Current and emerging infrastructure issues in developing countries etc. as well as other issues. The goal of JCPMI is to broaden the knowledge of construction professionals and academicians by promoting free access and providing valuable insight to construction-related information, research and ideas. JCPMI is a bi-annual publication and all articles are peer-reviewed.

Submission of Manuscript

Submit manuscripts as e-mail attachment to the Editorial Office at: caigbavboa@uj.ac.za, didibhukut@uj.ac.za. A manuscript number will be mailed to the corresponding author shortly after submission.

For all other correspondence that cannot be sent by e-mail, please contact the editorial office (caigbavboa@uj.ac.za, didibhukut@uj.ac.za).

The Journal of Construction Project Management and Innovation will only accept manuscripts submitted as e-mail attachments. Please read the Instructions for Authors before submitting your manuscript. The manuscript files should be given the last name of the first author.

Editor-in-Chief

Prof. Wellington Didibhuku Thwala
Professor of Construction Management
Department of Construction Management and Quantity Surveying
Faculty of Engineering and the Built Environment
University of Johannesburg
South Africa.

Editor

Prof. Clinton Ohis Aigbavboa
Associate Professor
Department of Construction Management and Quantity Surveying,
Faculty of Engineering and the Built Environment
University of Johannesburg
South Africa.

Guest Editor - Lean Construction in Africa (LCiA)

Prof. Fidelis Emuze
Associate Professor and Head: Built Environment
Head: Unit for Lean Construction and Sustainability
Faculty of Engineering and Information Technology
Central University of Technology, Free State
South Africa.

Editorial Board

Professor Peter Love
Curtin University, Australia

Professor Albert P.C. Chan
The Hong Kong Polytechnic University, Hong Kong

Prof. Charles Egbu
University of Salford, United Kingdom

Professor Nicholas Chileshe
University of South Australia, Australia

Professor David Carmichael
University of New South Wales, Australia

Professor Scott Fee
Minnesota State University, USA

Professor A.C. Ogbonna
Federal University of Technology, Akure, Nigeria

Dr E. Adinyira
Kwame Nkrumah University of Science and Technology, Kumasi, Ghana

Dr David Daw
North West University, South Africa

Professor Joshua Ayarkwa
Kwame Nkrumah University of Science and Technology, Kumasi, Ghana

Dr Geraldine Kikwasi
Ardhi University, Tanzania

Dr De-Graft Owusu-Manu
Kwame Nkrumah University of Science and Technology, Ghana

Professor Frank Fugar
Kwame Nkrumah University of Science and Technology, Kumasi, Ghana

Dr Lindile Ndabeni
Tshwane University of Technology, South Africa

Professor Alfred Talukhaba,
Tshwane University of Technology Pretoria, South Africa

Dr Jian Zuo
University of South Australia, Australia

Professor Hamimah Adnan
University Teknologi Mara, Malaysia

Professor Jun Ying Liu
Tianjin University, China

Professor Low Sui Pheng
National University of Singapore, Singapore

Dr Monty Sutrisna
University of Salford, United Kingdom

Professor John Smallwood
Nelson Mandela Metropolitan University Port Elizabeth, South Africa

Professor Christopher Harty
University of Reading United Kingdom

Professor Miklos Hajdu
Szent István University Hungary

Instructions for Author

Electronic submission of manuscripts is strongly encouraged, provided that the text, tables, and figures are included in a single Microsoft Word file (preferably in Arial font).

The **cover letter** should include the corresponding author's full address and telephone/fax numbers and should be in an e-mail message sent to the Editor, with the file, whose name should begin with the first author's surname, as an attachment.

Article Types
Three types of manuscripts may be submitted:

Regular Articles
All portions of the manuscript must be typed 1.5 spacing and all pages numbered starting from the title page. The font size must be 12.

Regular articles: These should describe new and carefully confirmed findings, and experimental procedures should be given in sufficient detail for others to verify the work. The length of a full paper should be the minimum required to describe and interpret the work clearly. The length of a full paper should be between 4000 – 7000 words. .
Review Process

Short Communications: A Short Communication is suitable for recording the results of complete small investigations or giving details of new models or hypotheses, innovative methods, techniques or apparatus. The style of main sections need not conform to that of full-length papers. Short communications are 2 to 4 printed pages (about 6 to 12 manuscript pages) in length.

Reviews: Submissions of reviews and perspectives covering topics of current interest are welcome and encouraged. Reviews should be concise and no longer than 4-6 printed pages (about 12 to 18 manuscript pages). Reviews are also peer-reviewed.

Review Process
All manuscripts are reviewed by an editor and members of the Editorial Board or qualified outside reviewers. Authors cannot nominate reviewers. Only reviewers randomly selected from our database with specialization in the subject area will be contacted to evaluate the manuscripts. The process will be blind review. Decisions will be made as rapidly as possible, and the journal strives to return reviewers' comments to authors as fast as possible. The editorial board will re-review manuscripts that are accepted pending revision. It is the goal of the JCPMI to publish manuscripts within the shortest possible time after submission.

Regular articles

All portions of the manuscript must be typed double spaced and all pages numbered starting from the title page.

The Title should be a brief phrase describing the contents of the paper. The Title Page should include the authors' full names and affiliations, the name of the corresponding author
along with phone, fax and E-mail information. Present addresses of authors should appear as a footnote.

The **Abstract** should be informative and completely self-explanatory briefly present the topic, state the scope of the experiments, indicate significant data, and point out major findings and conclusions. The Abstract should be 100 to 300 words in length. Complete sentences, active verbs, and the third person should be used, and the abstract should be written in the past tense. Standard nomenclature should be used and abbreviations should be avoided. No literature should be cited. Following the abstract, about 3 to 10 key words that will provide indexing references should be listed.

A list of non-standard **Abbreviations** should be added.
In general, non-standard abbreviations should be used only when the full term is very long and used often. Each abbreviation should be spelled out and introduced in parentheses the first time it is used in the text.

The Introduction should provide a clear statement of the problem, the relevant literature on the subject, and the proposed approach or solution. It should be understandable to colleagues from a broad range of scientific disciplines.

Materials and methods should be complete enough to allow experiments to be reproduced. However, only truly new procedures should be described in detail; previously published procedures should be cited, and important modifications of published procedures should be mentioned briefly. Capitalize trade names and include the manufacturer's name and address. Subheadings should be used. Methods in general use need not be described in detail.

Results should be presented with clarity and precision. The results should be written in the past tense when describing findings in the authors' experiments. Previously published findings should be written in the present tense. Results should be explained, but largely without referring to the literature. Discussion, speculation and detailed interpretation of data should not be included in the Results but should be put into the Discussion section

The Discussion should interpret the findings in view of the results obtained in this and in past studies on this topic. State the conclusions in a few sentences at the end of the paper. The Results and Discussion sections can include subheadings, and when appropriate, both sections can be combined.

The Acknowledgments of people, grants, funds, etc. should be brief.

Tables should be kept to a minimum and be designed to be as simple as possible. Tables are to be typed double- spaced throughout, including headings and footnotes. Each table should be on a separate page, numbered consecutively in Arabic numerals and supplied with a heading and a legend. Tables should be self-explanatory without reference to the text. The details of the methods used in the experiments should preferably be described in the legend instead of in the text. The same data should not be presented in both table and graph form or repeated in the text.

Figure legends should be typed in numerical order on a separate sheet. Graphics should be prepared using applications capable of generating high resolution GIF, TIFF, JPEG or Powerpoint before pasting in the Microsoft Word manuscript file. Tables should be prepared in Microsoft Word. Use Arabic numerals to designate figures and upper case letters for their parts (Figure 1). Begin each legend with a title and include sufficient description so that the figure is understandable without reading the text of the manuscript. Information given in legends should not be repeated in the text.

References: In the text, a reference identified by means of an author‘s name should be followed by the date of the reference in parentheses. When there are more than two authors, only the first author ‘s name should be mentioned, followed by ’et al‘. In the event that an author cited has had two or more works published during the same year, the reference, both in the text and in the reference list, should be identified by a lower case letter like ’a‘ and ’b‘ after the date to distinguish the works.

Examples:

Aigbavboa (2012), Aigbavboa et al. (2012), (Thwala, 2000), (Aigbavboa and Thwala, 2012), (Aigbavboa, 2008; Lesito, 2007a, b;

Aigbavboa, 2010, 2011), (Thwala et al., 2001)

References should be listed at the end of the paper in alphabetical order. Articles in preparation or articles submitted for publication, unpublished observations, personal communications, etc. should not be included in the reference list but should only be mentioned in the article text (e.g., A. Kingori, University of Nairobi, Kenya, personal communication). Journal names are abbreviated according to Chemical Abstracts. Authors are fully responsible for the accuracy of the references.

Examples:

Aigbavboa CO (2010). Residential satisfaction in low-income housing: a South Africa perspective. Journal of Construction Project Management and Innovation. 1(2): 14 – 20.

Aigbavboa CO, Lesito K (2012). ICT benefit in South Africa Construction Journal of Construction Project Management and Innovation. 2(2): 75 – 81.

Short Communications

Short Communications are limited to a maximum of two figures and one table. They should present a complete study that is more limited in scope than is found in full-length papers. The items of manuscript preparation listed above apply to Short Communications with the following differences: (1) Abstracts are limited to 300 words; (2) instead of a separate Materials and Methods section, experimental procedures may be incorporated into Figure Legends and Table footnotes; (3) Results and Discussion should be combined into a single section.

Proofs and Reprints: Electronic proofs will be sent (e- mail attachment) to the corresponding author as a PDF file. Page proofs are considered to be the final version of the manuscript. With the exception of typographical or minor clerical errors, no changes will be made in the manuscript at the proof stage.

Fees and Charges

No fee is paid for the publication of article(s) in JCPMI. Author's submissions are only required to meet the peer review process.

Copyright: © 2017, Sustainable Human Settlement and Construction Research Centre and the Department of Construction Management and Quantity Surveying- University of Johannesburg

All rights Reserved. In accessing this journal, you agree that you will access the contents for your own personal use but not for any commercial use. Any use and or copies of this Journal in whole or in part must include the customary bibliographic citation, including author attribution, date and article title.

Submission of a manuscript implies: that the work described has not been published before (except in the form of an abstract or as part of a published lecture, or thesis) that it is not under consideration for publication elsewhere; that if and when the manuscript is accepted for publication, the authors agree to automatic transfer of the copyright to the publisher.

Disclaimer of Warranties

In no event shall the management of the Journal of Construction Project Management and Innovation be liable for any special, incidental, indirect, or consequential damages of any kind arising out of or in connection with the use of the articles or other material derived from the JCPMI, whether or not advised of the possibility of damage, and on any theory of liability.

This publication is provided "as is" without warranty of any kind, either expressed or implied, including, but not limited to, the implied warranties of merchantability, fitness for a particular purpose, or non-infringement. Descriptions of, or references to, products or publications does not imply endorsement of that product or publication. While every effort is made by JCPMI management to see that no inaccurate or misleading data, opinion or statements appear in this publication, they wish to make it clear that the data and opinions appearing in the articles and advertisements herein are the responsibility of the contributor or advertiser concerned. JCPMI management makes no warranty of any kind, either express or implied, regarding the quality, accuracy, availability, or validity of the data or information in this publication or of any other publication to which it may be linked.

Table of Contents: Volume 7 Number 1 June, 2017

ARTICLES

Research Articles

A DISCOURSE ON LEAN CONSTRUCTION IN AFRICA, USING A SUPPLY CHAIN EXAMPLE

Fidelis EMUZE[1]

[1]Unit for Lean Construction and Sustainability, Department of Built Environment, Central University of Technology, Free State, South Africa, Email: femuze@cut.ac.za

ABSTRACT

A discourse is defined as a unit of speech or writing longer than a sentence. It is about knowledge and its construction within a group or domain. A discourse therefore tends to focus on how a particular phenomenon is represented within a social group. This special issue on lean construction in Africa (LCiA) is an attempt to highlight how the knowledge and practice of lean construction is understood by researchers in the region. This opening article opens the discourse with why implementation of lean supply chains should be encouraged in a sector where projects are delivered by multiple parties with different interests. The differences in project interests require application of supply chain management and lean principles to avert well-known construction problems. The subsequent articles in this special issue motivate for the use of lean construction concepts, and tools by practitioners in the region.

Keywords: construction, contractor, lean, supply chain

INTRODUCTION

Michel Foucault said that a discourse constitutes

> ways of constituting knowledge, together with the social practices, forms of subjectivity and power relations which inhere in such knowledge and relations between them. Discourses are more than ways of thinking and producing meaning. They constitute the 'nature' of the body, unconscious and conscious mind and emotional life of the subjects they seek to govern.[1]

This special issue of the *Journal of Construction Project Management and Innovation* on lean construction in Africa (LCiA) has been compiled to expose the little-known lean construction discourse on the continent. Construction in Africa has a history of poor project performance recorded on various types of immovable built environment assets. The net effect of cost overruns, time overruns, low productivity, accidents, building collapses, and defects is an industry that appears to be broken, when compared to the industry in other parts of the world. Although construction problems tend to be similar is different locations, the degree to which they occur, and their impact, differs from one place to another. Similarly, interventions that have been used to

[1] See explanations at http://michelfoucaultotago.blogspot.co.za/2012/09/discourses.html

tackle construction problems are accessible to most players in the industry worldwide. One such intervention is lean construction.

Since the 1990s, when Lauri Koskela published some of his seminal reports (e.g. Koskela, 1997), lean has been influencing design and production processes in the construction industry. Many regions of the world have, through empirical and industry papers, reported milestones in its implementation, where advances in cost, health and safety, quality, and time project performance have been demonstrated (Björnfot et al., 2011; Forbes and Ahmed, 2010; Rubrich, 2012; Salem et al., 2006). This is, however, not the case in Africa, where the Lean Construction Institute – South Africa (LCI–SA), which was launched in October 2015, is the only known community of practice (CoP) in the region.

The need for "more for less" project delivery paradigm has never been greater in Africa than it is now, where mineral benefaction, economic growth, and population expansion are fuelling activities in the construction industry. Media reports underpin the need for transformation and change, as anecdotal evidence and empirical reports overwhelmingly confirm that there are project delivery problems in the region (Emuze, 2011; Emuze and Smallwood, 2011a, 2011b, 2012, 2013; Flyvbjerg, 2008, 2009).

At either the conceptual and design stage or the construction and handover stage, performance remains a major issue for construction in Africa. It is therefore time to elevate the lean construction discourse in the region. This special issue presents articles that address the "why" and the "how" of lean construction in Africa, and this opening article uses these questions to highlight issues around implementation of the philosophy in the region. This special issue provides good-quality research papers on best-industry practices and case studies. The following is a list of the articles in this special issue:

- "A theoretical review of lean implementation within construction SMEs",
- "The state of adoption of lean construction in the Tanzanian construction industry",
- "An investigation into the usage of lean construction techniques in Nigeria",
- "Traces of lean construction practices in the indigenous building culture of the Talensi of northern Ghana",
- "The prospect of minimising production flow waste on construction sites in Nigeria through the Last Planner System",
- "A gemba kaizen model based on business process modelling and notation for small- and medium-scale construction businesses in Nigeria",
- "Nigerian construction-related professional services firms to adopt lean construction practices",
- "The influence of culture, beliefs, and experience on the sustainable end-of-life management of buildings in Nigeria",

- "A continuous improvement framework using IDEF0 for post-contract cost control", and
- "Modelling a conceptual framework of technology transfer process in construction projects: An empirical approach".

AN EXAMPLE OF WHY LEAN CONSTRUCTION IS NEEDED IN AFRICA

Supply chain management (SCM) is a system that originated in the manufacturing industry (Vrijhoef and Koskela, 2000). The construction sector adopted SCM to oversee, coordinate, and control the supply chain (SC) in the industry, guided by policy, principles, and specified methods. Although SCM is now common, there is evidence of failures (Deshpande, 2012). Akintoye et al. (2000) suggest that failure in SCM is as a result of workplace culture, lack of commitment by senior management, inappropriate support structures, and a lack of knowledge of the SCM philosophy. In construction, Lin (2011) indicates that experts in the field do not expect successful implementation of SCM without any restrictions being imposed on the system. Bankvall et al. (2010) corroborate this by stating that implementation of an SCM model could be challenging in the construction industry. A challenge cited is poor planning and management of the supply chain, due to project complexity (Cheng et al., 2010; Mehdi Riazi et al., 2011). As an illustration, non-value-adding activities, which are known as waste in the lean lexicon, are a problem that must be addressed by organisations if costs are to be significantly reduced, by ensuring that the production process is mistake-proof (Groznik and Maslaric 2009, as cited in Wiese et al., 2015).

The rationale for exploitation of SCM principles is based on the premise that the supply chain is a crucial element for the industry, as well as for firms within the industry. SCM has various characteristics, as shown in Table 1 (Pellicer et al., 2014). Among other goals, SCM seeks to promote cost efficiency, coordination of multiple structural activities, cooperation between multiple parties to a project, management of inventory (deployment of just-in-time delivery when required), integrative planning of required project tasks, and mutual sharing of information and knowledge among project parties.

Transformative approaches to the construction process will always be necessary as the industry evolves (Dües et al., 2013). For instance, contractors require effective methods, techniques and opportunities to acquire more work to keep the business afloat, to remain competitive, and to be sustainable in the industry's activities, apart from productivity improvement, which results from enhanced production planning. The characteristics outlined in Table 1 thus imply (Mentzer et al., 2001)

- A systems approach to viewing the supply chain as a whole, and to managing the total flow of inventory from the supplier to the ultimate customer,
- A strategic orientation towards cooperative efforts to synchronise and integrate intra-firm and inter-firm operational and strategic capabilities into a unified whole, and
- A customer focus, to create unique and individualised sources of customer value, leading to customer satisfaction.

Table 1: Widely known characteristics of supply chain management

Characteristic	Description
Cost efficiency	An evaluation of cost, which needs to be conducted to determine total cost advantages. This ensures allocation of savings in a productive manner.
Coordination of numerous levels	Three types of coordination must be considered across SC members, management levels, and functions,
Compatibility of corporate philosophies	Members need to agree on the basic directions of the SC. However, they need not agree on every procedure.
Inventory management approach	This aims to reduce inventory throughout the SC.
Joint planning	Members in the SC must participate in planning the flow of materials, so as to ensure that the SC develops a continuous process of planning, evaluation, and improvement.
Leadership	The SC must have leadership to develop and execute its core objective.
Information and knowledge sharing	Members in the SC must share information and knowledge in order to better manage the SC.
Risk management	Members in the SC must willingly and equally share/manage the risks associated with the SC.
Speedy operations	A reduction in cycle time increases the speed of operations.
Supplier base	The supplier base must be reduced so as to integrate and improve the SC.
Time prospects	This seeks durable time relationships, which will turn members into dedicated partners.

Source: Pellicer et al. (2014: 11).

METHOD AND RESULTS

Based on the highlighted benefits of SCM and lean, this example of LCiA provides a basis for assessing the question "What are the lean supply chain opportunities in South African construction?" The required empirical data were collected qualitatively. The results presented in the following subsection of this article were thus obtained from face-to-face interviews conducted with actors in a construction supply chain. The actors included supply chain managers, adjudication committee members, project managers, contractors and subcontractors, quantity surveyors, and suppliers. The sample comprised actors who represented various construction firms. Nine construction companies were identified from contractors based in Bloemfontein, South Africa. The companies were selected based on contracting capacity and whether they were accessible within the borders of South Africa. The research focused on companies that were engaged in infrastructure-related projects. However, only seven of the nine companies granted access to their facilities to participate in the study. Please see Table 2 for the background

information of the seven interviewees. All the contracting firms that participated in the study had been in the industry for more than 10 years, and most of them had specialised in civil engineering construction.

Table 2: Demographic information of interviewees

	Description							
Gender	Male		**4**		Female		**3**	
Age range	18–29	**2**	30–45	**5**	46–59	**0**	60+	**0**
Experience (in years)	1–5	**3**	6–10	**2**	11–15	**1**	16+	**1**
Qualifications	N6	**1**	N. Dip	**1**	Degree	**2**	Postgrad	**3**

Source: Author's own fieldwork, 2016.

General perceptions of lean in construction

The opening part of the interviews utilised a short questionnaire that examined perceived lean construction implementation challenges. A five-point Likert scale was used for the study, where 1 represented a minor challenge, and 5 represented a major challenge. Table 3 indicates that based on their working experiences, the interviewees rated limited involvement of construction workers as a major hurdle that must be overcome if lean, which is a people-based philosophy, is to make inroads in the sector.

Such limited involvement does not recognise lean principles that are to be applied and emphasised in practice for the full effect of the concept. Implementation challenges that were rated as significant challenges by the interviewees include limited knowhow and buy-in among managers and supervisors, non-integration of the construction supply chain, a poor industrial culture in the working environment, and poor commitment to change and innovation in the industry. Other challenges that were rated as significant were qualifications of work team members, resistance to change the organisational structure, lack of motivation at individual, team and organisational levels, underdevelopment of the enterprise's vision and goals, and improper conceptualisation of lean construction tools and methods.

Although the recorded mean scores were not that much lower, the lowest-ranked challenges related to the need to tackle challenges. They were lack of leadership and management support, fear of losing job and the cost of retraining, the need for employment and labour-intensive construction, and non-availability of useful local knowledge and expertise, in ascending order of mean scores. It is worth noting that the job-related challenges confirm the findings of earlier empirical work conducted in South Africa (Emuze and Ungerer, 2014; Emuze and Van Linde, 2015), namely that inaccurate perceptions of the fundamentals of lean appear to perpetuate resistance to change.

Table 3a: Perceptions of lean construction implementation challenges

Implementation challenge	Mean Score	Rank
Limited involvement of construction workers	4.00	1
Limited knowhow and buy-in among managers and supervisors	3.93	2
Non-integration of the construction supply chain (contractors, designers, subcontractors, etc.)	3.93	3
A poor industrial culture in the working environment	3.87	4
Poor commitment to change and innovation in the industry	3.87	5
Qualifications of work team members	3.80	6
Resistance to change the organisational structure	3.80	7
Lack of motivation at individual, team and organisational levels	3.80	8
Underdevelopment of the enterprise's vision and goals	3.79	9
Improper conceptualisation of lean construction tools and methods	3.77	10
Resistance to change the organisational culture	3.73	11
Resistance to change among experienced artisans	3.71	12
Time constraints due to close deadlines	3.67	13
Resistance to change work processes	3.67	14
Underdeveloped technical competence	3.64	15
Inadequate information within work teams	3.57	16

Source: Author's own field survey, 2016.

To confirm their familiarity with lean concepts, the interviewees were requested to rate their use of 12 lean construction tools. In general, the results show that the tools are not in use in the firms that participated in the study. The tools assessed were weekly work plan, team organisation, flow chart, process planning, brainstorming, problem identification, lookahead planning, cycle time, effective meetings, training plan, failure-prevention analysis, and fishbone diagram. Having obtained general perceptions on lean matters, the researcher engaged individual interviewees in in-depth discussion about lean SCM. As mentioned earlier, lean as a philosophy has been in existence for over six decades. However, the majority of the interviewees in the South African study did not know about lean. Perhaps this is the reason for the non-utilisation of the lean tools mentioned in the questionnaire. It is therefore important to state that before implementation of

lean as a concept, and its tools, people will need to be properly trained, so that the full potential of lean in a project environment can be realised.

Table 3b: Perceptions of lean construction implementation challenges

Implementation challenge	Mean Score	Rank
Resistance to change project implementation structure	3.53	17
Lack of training for contractors and their subcontractors	3.53	18
Underestimation of education and training needs	3.50	19
Lack of communication within work teams	3.47	20
Underdeveloped social competence	3.43	21
Poor collaborative working relations between clients, designers, and contractors	3.43	22
The pervasiveness of craft construction	3.43	23
Incorrect interpretations of the Last Planner System (LPS) of production	3.43	24
Inadequate role definition within project teams	3.40	25
Lack of resources – financial and non-financial	3.40	26
Lack of adequate awareness and understanding in firms and the industry as a whole	3.40	27
Behavioural and human-attitudinal issues	3.40	28
Non-availability of useful local knowledge and expertise	3.33	29
Need for employment and labour-intensive construction	3.33	30
Fear of losing job and the cost of retraining	3.27	31
Lack of leadership and management support	3.20	32

Source: Author's own field survey, 2016.

In fact, only two interviewees confirmed that they knew about lean construction. The two interviewees understood it as an application, and a new form of management, which sets goals for project delivery, in the pursuit of performance. Further, they understood it as a concept, which makes construction processes easier, while at the same time reducing operational costs. There was no difference in the poor understanding of lean SCM among the interviewees, where only one interviewee could comment on it. The limited understanding of lean SCM among the interviewees

was confined to processes that need to be changed. These included, but were not limited to, waiting time, with specific reference to waiting time for required information, and approval and issuing of designs and the like. The fact that most of the interviewees were not familiar with lean and its accompanying processes emphasises the need for education and training in lean construction. The single interviewee that appeared to be knowledgeable about lean construction said that opportunities to improve performance could accrue from implementation. The opportunities mentioned by the interviewee included aligning the supply chain with the business strategy, inventory management, procurement optimisation, demand-driven production, supplier selection, and regional distribution centre selection.

Factors responsible for resistance to change

In this section, the interviewees were required to discuss what could be causing resistance to change regarding adoption of processes such as lean construction. The most discussed point related to perceived job losses due to implementation of new methods of work. Interviewee 1 opined that lean construction could potentially lead to redundancies. The interviewee went on to say that there is no need for lean to be implemented at all. Interviewee 4 shared these sentiments, citing the introduction of a particular plant, which this participant feels threatens human employment. Interviewee 5 had similar perceptions to those of interviewee 1 and interviewee 4. This participant was of the view that upon implementation of lean, jobs will be lost, because of optimal use of plants and equipment. Interviewee 2, however, had a completely different perception. The participant perceived that use of new tools and methods is not a bad idea, given the fact that South Africa still has many opportunities to grow. To support the view that introduction of new tools and methods in the sector is not a bad idea, this participant indicated that there will be less wastage, which will, in turn, make it possible for money to be spent on more projects, thus increasing job creation.

In light of the above, it is evident that the majority of the participants are of the opinion that introduction of new tools and methods could potentially lead to job losses. This fear is, however, unfounded, as lean is not about mechanisation, but about people and culture (Rubrich, 2012; Santorella, 2011).

AN ILLUSTRATION OF HOW TO PROMOTE LEAN CONSTRUCTION

From the collected SCM data, the reviewed literature, and the articles in this special issue, it is clear that all stakeholders should endeavour to encourage education and training, so as to promote dissemination of the information required for lean implementation. For instance, none of the interviewees in the SCM example provided in this article had received learning with regard to lean. The learning suggestion is relevant, as all of the interviewees confirmed their readiness to obtain knowhow that will inspire confidence in their employers. Such knowledge should be able to embed practices that break down resistance to change in their firms. Respect for people is a principle of lean that will assist in breaking down barriers.

Respect for people can be seen in action when people are allowed to take initiative on assigned tasks. In particular, the interviewees in the SCM study contended that to ensure that employees improve their level of confidence in their work activities, it is wise to give them room to manage their work, with minimal or no supervision. This idea from the interviewees is a cornerstone of lean construction practice. The implication of this idea is that the region has practices upon which lean construction tools and concepts can be built. Building on what is known will accelerate

transfer of knowledge, while improving on-site project performance. Lean offers a system of project delivery where contractors are allowed to compete in a less fragmented and adversarial manner. In North America, Europe, Asia, Australia, and South America, where lean construction has had a major impact on project delivery, the industry and academia have worked together to realise improved performance. It is therefore time to promote the lean construction discourse in Africa.

What is most important to Africa is employment, and fear of job losses is a reality in practice. Implementation of lean construction does not, however, translate into job losses. Given the people-centred culture of lean construction, the concept should not be seen as a potential source of job losses if it is adopted. Fear of job losses resulting from lean construction is a myth, which proper education and training can debunk in the industry. Realisation of the opportunities inherent in lean can begin with use of its tools on projects by contractors and their supply chain. Although implementation of lean promises to improve practice, by reducing and eliminating waste, it is prudent to also promote the notion of continuous improvement. Future work should begin to report on lean implementation case studies in the region.

ACKNOWLEDGEMENTS

In developing this article, the author has drawn on treatises produced with his instruments by his students in 2016. The author gratefully acknowledges the contributions of Lucky Madisha and Kelebogile Thahetse. This article was also language-edited by a freelance language editor, Anthony Sparg. He has edited several academic journal articles and master's theses in the field of construction management. He has an MA *cum laude* in African Languages (isiXhosa), an MA *cum laude* in Linguistics, and a Higher Diploma in Education. The acknowledgement is also extended to lean construction researchers that peer reviewed the articles in this special issue. I am grateful to the following colleagues:

- Abdulhakeem Garba – Robert Gordon University.
- Ayman Othman - British University in Egypt.
- Chien-Ho Ko – National Pingtung University of Science and Technology.
- Daniela Dietz Viana - Federal University of Rio Grande do Sul.
- Dayana Bastos Costa - Federal University of Bahia.
- Farook Hamzeh – American University of Beirut.
- John Ameh – University of Lagos.
- John Rooke – Formerly of University of Salford.
- Lincoln Forbes – Florida International University.
- Muhamad Abdul - Institut Teknologi Bandung.
- Patricia Tzortopoulous – University of Huddersfield.
- Paz Arroyo – Pontifica Universidad Catolica de Chile.
- Saad Sarhan – Nottingham Trend University.
- Tarcisio Saurin – Federal University of Rio Grande do Sul.

REFERENCES

Akintoye, A., McIntosh, G. and Fitzgerald, E. (2000). A survey of supply chain collaboration and management in the UK construction industry. *European Journal of Purchasing & Supply Managemen*t, 6(3–4), 159–168.

Bankvall, L., Bygballe, L. E., Dubois, A. and Jahre, M. (2010). Interdependence in supply chains and projects in construction. *Supply Chain Management: An International Journal*, 15(5), 385–393.

Björnfot, A., Bildsten, L., Erikshammar, J., Haller, M. and Simonsson, P. (2011). Lessons learned from successful value stream mapping (VSM). *Proceedings of the 19th Annual Conference of the International Group for Lean Construction*, 13–15 July. Lima, Peru.

Cheng, J. C. P., Law, K. H., Bjornsson, H., Jones, A. and Sriram, R. (2010). A service oriented framework for construction supply chain integration. *Automation in Construction*, 19(2), 245–260.

Deshpande, A. (2012). Supply Chain Management Dimesnions, Supply CHain Performance and Organisational Performance: An Integrated Framework, *International Journal of Business and Management*, 7(8), 8-9.

Dües, C. M., Tan, K. H. and Lim, M. (2013). Green as the new Lean: How to use Lean practices as a catalyst to greening your supply chain. *Journal of Cleaner Production*, 40, 93–100.

Emuze, F. A. (2011). *Performance improvement in South African construction*. PhD thesis. Port Elizabeth: Nelson Mandela Metropolitan University.

Emuze, F. and Smallwood, J. (2011a). Criticality of intelligent clients in the infrastructure sector. *Proceedings of the Institution of Civil Engineers: Municipal Engineer*, 164(4), 251–257.

Emuze, F. and Smallwood, J. (2011b). Improving project delivery in South African construction. *Proceedings of the 27th Annual Association of Researchers in Construction Management (ARCOM) Conference*. 5–7 September. Bristol, UK. pp. 921–930.

Emuze, F. and Smallwood, J. J. (2012). Bridging public works project performance gaps in South Africa. *Proceedings of the Institution of Civil Engineers: Management, Procurement and Law*, 165(2), 111–118.

Emuze, F. A. and Smallwood, J. J. (2013). Management concepts and project performance: Perceptions from the South African public sector environment. *Journal of the South African Institution of Civil Engineering*, 55(2), 21–28.

Emuze, F. A. and Ungerer, H. P. (2014). Change in South Africa construction: Lessons from lean thinking. *Proceedings of the 22nd Annual Conference of the International Group for Lean Construction*. 24–27 June. Oslo, Norway. pp. 1121–1131.

Emuze, F. A. and Van Linde, C. (2015). Lean construction in South Africa: Myth or reality? *Proceedings of the 8th International Conference on Construction in the 21st Century*. 27–30 May. Thessaloniki, Greece. pp. 455–461.

Flyvbjerg, B. (2008). Curbing optimism bias and strategic misrepresentation in planning: Reference class forecasting in practice. *European Planning Studies*, 16(1), 3–21.

Flyvbjerg, B. (2009). Survival of the unfittest: Why the worst infrastructure gets built—and what we can do about it. *Oxford Review of Economic Policy*, 25(3), 344–367.

Forbes, L. H. and Ahmed, S. M. (eds). (2010). *Modern construction: Lean project delivery and integrated practices*. Boca Raton, FL: CRC Press.

Koskela, L. (1997). Lean production in construction. In: L. Alarcon (ed.). *Lean construction*. Rotterdam: Balkema. pp. 1–9.

Lin, L. (2011). *Supply chain quality management for subcontracting systems in the construction industry*. MEng thesis. Wollongong, New South Wales: University of Wollongong.

Mentzer, J. T., DeWitt, W., Keebler, J. S., Min, S., Nix, N. W., Smith, C. D. and Zacharia, Z. G. (2001). Defining supply chain management. *Journal of Business Logistics*, 22(2), 1–25.

Pellicer, E., Yepes, V., Teixeira, J. C., Moura, H. P. and Catala, J. (2014). *Construction management*. Oxford: Wiley-Blackwell.

Mehdi Riazi, S., Skitmore, M. and Cheng, Y. K. F. (2011). The use of supply chain management to reduce delays: Malaysian public sector construction projects. *Proceedings of the 6th Nordic Conference on Construction Economics and Organisation in Society, vol. 2*. Danish Building Research Institute, Aalborg University, Copenhagen. pp. 403–414.

Rubrich, L. (2012). *An introduction to lean construction: Applying lean to construction organizations and processes*. Fort Wayne, IN: WCM Associates.

Salem, O., Solomon, J., Genaidy, A. and Minkarah, I. (2006). Lean construction: From theory to implementation. *Journal of Management in Engineering*, 22(4), 168–175.

Santorella, G. (2011). *Lean culture for the construction industry: Building responsible and committed project teams*. Boca Raton, FL: CRC Press.

Vrijhoef, R. and Koskela, L. (2000). The four roles of supply chain management in construction. *European Journal of Purchasing & Supply Management*, 6(3–4), 169–178.

Wiese, A., Luke, R., Heyns, G. J. and Pisa, N. M. (2015). The integration of lean, green and best business principles. *Journal of Transport and Supply Chain Management*, 9(1), 1–10.

A THEORETICAL REVIEW OF LEAN IMPLEMENTATION WITHIN CONSTRUCTION SMEs

Emmanuel Nsiah ANKOMAH[1], Joshua AYARKWA[2], and Kofi AGYEKUM[3]

[1]Department of Building Technology, Kwame Nkrumah University of Science and Technology (KNUST), Kumasi, Ghana, Email: bd310nsiah@gmail.com
[2]Department of Building Technology, KNUST, Kumasi, Ghana, Email: jayarkwa.cap@knust.edu.gh
[3]Department of Building Technology, KNUST, Kumasi, Ghana, Email: agyekum.kofi1@gmail.com

ABSTRACT

Small- and medium-sized enterprises (SMEs) are considered the backbone of many economies. SMEs constitute over 90% of global enterprises and account for about 60% of employment. However, SMEs still suffer from many problems, such as low product quality and working efficiency, budget overruns, and substantial construction waste. Lean construction has increasingly been implemented as a potential solution for organisations to deal with waste of all types. The aim of this article is to suggest lean tools that can be implemented within the construction SME set-up. A systematic review of empirical and theoretical studies obtained from ResearchGate, International Group for Lean Construction (IGLC) conference proceedings, ScienceDirect (Elsevier), Emerald Insight, Taylor & Francis Group, Google Scholar, and other Internet sources was conducted in this study. This paper was based on four hypotheses, which are related to construction SMEs' capacity to implement lean as efficiently as large enterprises do. The study found that lean was applicable in construction SMEs, but that it has to be contextualised within the peculiar characteristics of the SME, such as its size, financial capabilities, organisational culture, and human resource capacity. The paper concluded by recommending lean tools such as 5S, A3 problem solving, and 5 Whys, which require less monetary investment to be implemented by construction SMEs. A change of mindset is needed for lean implementation, as there is still a low rate of lean adoption among SMEs.

Keywords: SMEs, lean construction, process improvement, value, innovation

INTRODUCTION

The performance of the construction industry in Ghana is poor, and it experiences several problems, ranging from contract administration difficulties to complex and lengthy payment procedures, from delayed payments to project execution challenges

(Anvuur et al., 2006). The construction industry in Ghana is dominated by small- and medium-sized enterprises (SMEs), which are characterised by high attrition rates. These are the least organised of enterprises, and their performance is usually below expectations. In essence, there is not much difference between the problems militating against the construction industry in Ghana regarding project execution and performance and the problems experienced in the construction industry in other developing countries. The main difference, however, is that Ghana is yet to take the necessary steps to address the problems (Gyadu-Asiedu, 2009).

Small- and medium-sized enterprises (SMEs) are one of the most significant forces for economic growth. SMEs are recognised worldwide as vital in the stimulation of innovation, economic growth, job opportunities, and poverty reduction, and they support large-scale enterprises. SMEs account for approximately 90% of businesses and more than 50% of employment worldwide. In developing countries, SMEs account for 45% of formal employment (Bauchet and Morduch, 2013). SMEs are also believed to contribute about 70% to Ghana's GDP, and to account for about 92% of businesses in Ghana (Ackah and Vuvor, 2011). Therefore, the contribution of this sector to the economy of Ghana cannot be overemphasised.

Notwithstanding these contributions, SMEs still suffer from many fundamental problems, such as low product quality, low working efficiency and projects being completed over budget, and huge construction waste, among other things. Lean construction is a potential solution to the many problems faced within the industry, and it results in exceptional performance improvement (Bhamu and Sangwan, 2014). Yet there is still a low rate of lean adoption by construction SMEs, both in Ghana and in other countries. This problem has always been attributed to the fact that SMEs lack the capacity to implement such a management philosophy. In some earlier studies, it was revealed that SMEs do not have the capacity to implement lean construction (Shang, 2013; Ayarkwa et al., 2012). Construction SMEs, and the industry as a whole, have been criticised by many for limited collaborative working ethos, their slow uptake of new technologies and processes, and issues associated with organisational management (Miller et al., 2002). Considering the investment levels of the construction industry, and the development needs of most developing countries, attention to these matters is long overdue. Construction SMEs constitute the largest group in the construction industry, and their performance impacts greatly on the performance of the industry as a whole (Gyadu-Asiedu, 2009). Therefore, any improvement efforts to SMEs will impact greatly on the performance of the industry as a whole.

Any method that seeks to make an enterprise lean always reduces waste and maximises value in the company, enhancing core resources and establishing a corporate culture dedicated to identifying and continuously promoting customer satisfaction (Arroyo and Gonzalez, 2016). The principles in making an enterprise lean can be categorised as identifying value, eliminating waste, and generating smooth flow (Azharul and Arif-Uz-Zaman, 2013). It appears, however, that there is a significantly lower rate of adoption of lean principles in SMEs than in large enterprises (LEs) (Shah and Ward, 2003), and that many SMEs are still unfamiliar with lean implementation (Achanga et al., 2006).

RESEARCH METHODOLOGY

The article was developed based on a review of empirical and theoretical studies already published. Past research on lean construction and SMEs was obtained primarily from research databases, including ResearchGate, IGLC conference proceedings, ScienceDirect (Elsevier), Emerald Insight, Taylor & Francis Group, Google Scholar, and other Internet sources. The initial descriptors used for the search were "lean construction tools", "construction SMEs", and "lean and construction SMEs". The initial descriptors were used to search the databases. A total of 75 articles were reviewed for the research. This work is based on four research questions, which are related to construction SMEs' capacity to implement lean as efficiently as large enterprises do. The questionss are: "Does the size of the firm matter in lean adoption and implementation?"; "Can SMEs benefit from lean if they apply the lean package only partially?"; "Can SMEs benefit from lean, considering their organisational structure and culture, and their financial and human resource capacities?"; and "Is the organisational culture of construction SMEs in Ghana supportive of lean construction?" The article seeks to answer these questions, and it goes on to recommend lean tools that can be implemented by construction SMEs in Ghana.

THE NEED FOR LEAN IMPLEMENTATION IN CONSTRUCTION SMEs

Construction is one of the world's major industries, and it is normally recognised as having high levels of waste (Bølviken and Koskela, 2016). There is a need for construction SMEs to be aware of lean and to be able to motivate their employees, clients, and partners to attain greater joint performance (Ofori and Toor, 2012).

This, the authors believe, can be achieved through implementation of lean construction principles in construction SMEs in Ghana. There have been a number of reviews of literature on lean. For example, Moyano-Fuentes and Sacristán-Díaz (2012) developed a general framework for lean, and, most recently, Shang (2013), in his PhD thesis, proposed a lean implementation framework for large construction companies in China. These reviews have largely focused on lean in general, or they have focused on larger enterprises, neglecting smaller ones. There is thus a gap in the literature on lean that is pertinent to SMEs. Given the nature of the contingency management approach, it follows, then, that a management philosophy such as lean construction is contingent upon the characteristics of each unique organisation. The fact that such management practices have worked well for large enterprises does not necessarily mean that they will work well in SMEs. It is more important to adjust where necessary to better suit the peculiar characteristics of SMEs. Studies conducted within the construction industry in Ghana suggest a low level of familiarity and application of lean construction among practitioners within the industry (Ankomah et al., 2015; Ayarkwa et al., 2012).

Rose et al. (2011) pointed out that there is currently no standard measure for lean implementation that SMEs can adopt. Although different researchers have different perspectives on the issue, they stress that SMEs should opt for the least costly practices, such as 5S, visual management (VM), etc. SMEs face challenges in their processes of production, and this makes the implementation of lean in construction

worth exploring.

LEAN APPLICABILITY WITHIN CONSTRUCTION SMEs

This paper is based on four hypotheses, which are related to construction SMEs' capacity to implement lean as efficiently as large enterprises do.

Does size of the firm matter in lean adoption and implementation?

There is still considerable interest as to whether there is a difference in the applicability of lean between large enterprises (LEs) and SMEs (Rose et al., 2013). It is the subject of continued debate whether the size of a firm is a critical factor in lean implementation. Many authors have suggested that lean is more suitable for large enterprises than for SMEs (e.g. Shah and Ward, 2003; Achanga et al., 2006). The researchers argue that implementation of lean by SMEs is a challenge, due to their lack of required resources and capabilities. However, other researchers disagree, asserting that size does not affect a firm's ability to implement lean, and that SMEs can implement these systems as effectively as large organisations do (Rose et al., 2011). They go on to assert that SMEs can implement lean, but that they should opt for the least costly practices. The authors' provisional proposition is that the size of the firm does not really matter. Small firms, by virtue of their size, can implement some lean tools for their own benefit, but they need to opt for tools that require less investment.

Can SMEs benefit from lean if they apply the lean package only partially?

Although some researchers (e.g. Liker, 2004; Anand and Kodali, 2009) have suggested that lean practices should be implemented as a full package, Golicic and Medland (2007) have argued otherwise. The researchers believe that lean can be applied partially. Application of some lean tools will lead to gradual performance improvements in SMEs, which can then lead to more advanced practices (Rose et al., 2011).

Can SMEs benefit from lean, considering their organisational structure and culture, and their financial and human resource capacities?

At the financial level, SMEs lack the funding (Mazanai, 2012) and infrastructure/facilities (Panizzolo et al., 2012) needed to implement lean. Ongoing implementation of the full version of lean can require substantial investment before benefits are realised, and SMEs may be more restricted in this regard in terms of available financial resources or ability to invest upfront in sufficient time to support training and knowledge development (Mazanai, 2012).

SMEs can implement some of the tools, such as the Last Planner, 5S, etc., to enhance their performance and productivity. SMEs can do this without having to invest huge sums of money. As the SMEs grow, they can implement other tools that require substantial investment, such as building information modelling (BIM).

Is the organisational culture of construction SMEs in Ghana supportive of lean construction?

The construction industry differs culturally from one country to another, and

therefore practices and procedures that are well suited to the culture of one country may not be suitable in other countries (Kheni, 2008). Evidence from the literature suggests that an organisation cannot succeed in lean unless it has a healthy culture. In the UK, only 10% of firms succeed in their lean implementation efforts. The reason behind the low success rate is culture and management (Taleghani, 2010). Culture is a vital factor for successful lean implementation (Al-Swidi and Mahmood, 2011). Dahlgaard and Dahlgaard-Park (2006) have argued that appropriate culture cannot be compromised if a company wants to adopt lean successfully. A discussion of organisational culture is appropriate, as lean initiatives are normally undertaken at the organisation level, where changes occur away from the traditional management approaches to construction (Shang, 2013). According to Atuahene (2016), small firms in Ghana have a dominance hierarchy culture focused on internal structures. The relationship between contractors and suppliers within the industry is also short-term, and only based on the needs of current projects (Ankomah et al., 2015).

Lean construction requires a culture of employee empowerment, teamwork, and enhanced relations with employees and suppliers (Womack et al., 1990). Companies that have successfully implemented lean have argued that it would not have been possible without sustained employee and supplier engagement and support at all levels of the organisation (Korb, 2016). Hierarchical structure, along with a top-down leadership style, is one of the many cultural barriers that cause lean initiatives to fail (Shang, 2013). The organisational culture in the construction industry in Ghana will need to change if the industry is to accommodate lean initiatives.

LEAN PRACTICES

Table 1 identifies lean practices applicable to construction, with a brief description of the tools, and the literature sources consulted. The categorisation was mostly informed by an analysis of IGLC conference proceedings, although other studies published elsewhere were also consulted.

Table 1A. Identified lean practices applicable to construction, description of the tools and references

Lean tools	Brief description	References
Last Planner System	The Last Planner™ System (LPS™) provides a regimented process of achieving reliable workflow on simple and complex construction projects. This system was created in order to improve the predictability and reliability of construction production.	Toledo et al., (2016); Habchi et al., (2016); Salem et al., (2005)
Increased Visualisation	It is about communicating key information effectively to the workforce through posting various signs and labels around the construction site. This includes signs related to safety, schedule, and quality.	AlNimr and Mohammed (2010); Salem et al., (2005)
Daily Huddle	Daily huddles are for communication, not only for managers to talk to employees, but also for employees to	Salem et al., (2005)

Meetings	express themselves and learn from each other.	
5S Process	5S is a basic method for clean-up and organisation of the workplace.	Tezel et al., (2016); Berrior et al., (2015)
5 Why's	It works by asking once why an effect happened, and to the response of that question, ask again, why it happened. Same procedure is repeated until asking five times why it happened and by the end of the process, the answer is the root cause.	Fuenzalida et al., (2016); Kemmer et al., (2006)
Concurrent Engineering	A simultaneous engineering that attempts to optimise the design of a project and its construction process by the integration of design, fabrication, construction and erection activities.	Knotten et al., (2014)
Choosing by Advantages (CBA)	CBA is a value-based Multi-Criteria Decision- Analysis system that supports sound decision-making based on the comparisons among the advantages of alternatives.	Kpamma et al., (2014)
Building Information Modelling (BIM)	A virtual process that encompasses all aspects, disciplines, and systems of a facility within a single, virtual model. Some new concepts and BIM applications have been developed for different purposes in the construction industry, such as 4D, 5D, 6D and 7D dimensions	Abou-Ibrahim and Hamzeh (2016); Harris and Alves (2016)
Kaizen	Kaizen is a Japanese word for improvement. This Lean construction tool involves looking at some task in the field and finding out how to do it better, more efficiently, safer and quicker.	Rossiti et al., (2016); Liker and Meier (2006)
Poka-Yoke	In building a culture of stopping to fix problems, poka-yoke is one of the lean tools that help the employees to detect the defects and halt the process. It is synonymous with fail safe for quality and safety.	Shang (2013); Tommelein (2008)
A3 Report	An A3 is an orderly document that aids thinking. A3 reports are so named because they fit on one side of an A3 size paper. The A3 report is a way of representing an action course, in which goals, methodology, agents involved and others are included. The document is for problem solving, proposing action or project status reporting.	Fuenzalida et al., (2016); Rybkowski et al., (2016); Koskela (2015)

Table 1B. Identified lean practices applicable to construction, description of the tools and references

Lean tools	Brief description	References
The Ishikawa	The Ishikawa diagram is a representation of a	Fuenzalida et al., (2016)

diagram	cause-effect analysis that is carried out for any type of result.	
Location Based Management System (LBMS)	The Location Based Management System (LBMS) provides a much needed spatial element to planning and has strong optimization and forecasting capability that can help plan and steer the project towards its goals.	Dave et al., (2016); Frandson et al., (2015)
Andon	A visual control tool which shows the operation status and signalize the occurrence of abnormalities.	Biotto et al., (2014); Kemmer et al., (2006)
Heijunka	Leveling the work flow of a production system and balancing or distributing load and capacity	Alves et al., (2009); Barbosa et al.,(2013)
Value Stream Mapping	Systemic view of the production process (of the value flow), identification of real problems and wastes and proposition of improvements.	Murguia et al.,(2016); Covarrubias et al., (2016)
Material Kanban Cards	It is used as a material process flow technique for the pull replenishment logic system.	Jang and Kim (2007)
Six Minute Exchange Die (SMED)	SMED practices in project management can be seen as a method for fast tracking the project schedule.	Antunes et al.,(2016)
Action Learning	The core idea behind Action Learning is to create small, mutually supportive groups (known as SETs) of people who band together to solve real problems or difficulties which are not solved in current best practice.	Hirota and Formoso (2001)

Based on the lean construction tools identified within the literature cited in Table 1, the authors categorised these tools into three groups, namely

A. Tools that require less monetary investment to implement,
B. Tools that can be fully implemented by construction SMEs, and
C. Tools that can be partially implemented by SMEs.

The categorisation has been done for the purposes of suggesting lean construction tools for use by SMEs based on their peculiar characteristics. The contents of Table 2 are based on the categorisation as indicated above.

Table 2. Three groups of lean tools

Group / Lean tool	A	B	C
Last Planner System	×	×	
Increased visualisation	×	×	

Daily huddle meetings	×	×	
First-run studies	×	×	
5S process	×	×	
5 Whys	×	×	
Concurrent engineering	×	×	
Choosing by Advantages (CBA)	×	×	
Building Information Modelling (BIM)			×
Kaizen	×	×	
Poka-yoke	×	×	
A3 report	×	×	
The Ishikawa diagram	×	×	
Location-Based Management System (LBMS)	×	×	
Andon	×	×	
Heijunka	×	×	
Value stream mapping (VSM)	×	×	
Material kanban cards	×	×	
Single-minute exchange of dies (SMED)	×	×	
Action learning	×	×	

Researchers such as Rose et al. (2011) and Salem et al. (2005) have confirmed that tools such as 5S, kanban cards, SMED, kaizen, increased visualisation, Last Planner, daily huddle meetings, first-run studies, poka-yoke, and andon are the least costly, and can be implemented by SMEs. A review of the literature on the other lean construction tools (5 Whys, concurrent engineering, Choosing by Advantages, A3 report, the Ishikawa diagram, LBMS, heijunka, VSM, and action learning) shows these tools as not being capital-intensive, and therefore not within the reach of SMEs. The authors will subsequently validate these other lean construction tools. Considering the poverty levels in Ghana, the authors recommend that lean tools that require less monetary investment be implemented by construction SMEs, as can be seen in Table 2. SMEs can implement these tools without having to invest that much, and as the SME grows, it can implement tools such as BIM, which requires some investment in software and hardware. SMEs can implement some aspects of BIM, such as 3D, which does not require substantial investment.

ADOPTING LEAN PRACTICES BY CONSTRUCTION SMEs IN GHANA

A change in mindset is required before embarking on lean implementation (Herrala et al., 2012; Emuze and Ungerer, 2014). This is because a fundamental part of implementing any lean strategy is a change of mindset, and a change of organisational culture (Liker and Meier, 2006). Top management must intervene, and this requires that people behave differently, starting with changing their conventional mindsets. As this process is repeated, a different set of beliefs and values – a new organisational culture – will ultimately evolve. This, however, requires a long-term

commitment to continuous improvement. Professional bodies, such as the Ghana Institute of Architects (GIA), the Ghana Institution of Surveyors (GhIS), and the Ghana Institution of Engineers (GhIE), should expose their members to the concept of lean thinking, through their continuing professional development programmes. There could also be collaboration with leading institutional proponents of lean construction, such as the Lean Construction Institute (LCI), to offer special training for contractors in Ghana on strategies for applying the lean thinking concept within the industry. Furthermore, there should be deliberate government policy to implement lean, particularly within public-sector construction works. There is also a need for research and teaching to be strengthened in the academic and professional training of students pursuing construction-related disciplines.

CONCLUSIONS

The global economy is changing, and is becoming much more competitive. The benefits of implementing lean are substantial, while the cost of not being able to meet project goals may be significant. The primary objective of this paper was to propose lean construction tools that can be implemented within the construction SME set-up. This is against the backdrop of SMEs' lack of the needed resources to implement lean construction. Through a review of the literature, this paper has proposed lean construction tools that can be implemented within the construction SME set-up. The study found that SMEs can implement some lean tools, such as the Last Planner, 5S, etc., which will not require having to invest huge sums of money. This is an important finding, as some authors have argued that SMEs do not have the capacity to implement lean construction. This is preliminary research from an ongoing PhD, which aims to develop a lean implementation framework to enhance the performance of construction SMEs. The findings in this study will be validated through a nationwide survey, case studies, and interviews in Ghana.

ACKNOWLEDGEMENT

This article was language-edited by a freelance language editor, Anthony Sparg. He has edited several academic journal articles and master's theses in the field of construction management. He has an MA *cum laude* in African Languages (isiXhosa), an MA *cum laude* in Linguistics, and a Higher Diploma in Education.

REFERENCES

Abou-Ibrahim, H. and Hamzeh, F. (2016). BIM: A TFV perspective to manage design using the LOD concept. *Proceedings of the 24th Annual Conference of the International Group for Lean Construction*. Boston, MA. Section 4. pp. 3–12. Available at: www.iglc.net

Achanga, P., Shehab, E., Roy, R. and Nelder, G. (2006). Critical success factors for lean implementation within SMEs. *Journal of Manufacturing Technology Management*, 17(4), 460–471.

Ackah, J. and Vuvor, S. (2011). *The challenges faced by small & medium enterprises (SMEs) in obtaining credit in Ghana*. A dissertaion submitted to Blekinge Institute of Technology, Karlskrona, Sweden, for the award of master's degree.

AlNimr, A. and Mohammed, Y. (2010). Application of gaming engines in simulation driven visualization of construction operations. *ITcon*, 16, 23–38.

Al-Swidi, A. K. and Mahmood, R. (2011). How does organizational culture shape the relationship between entrepreneurial orientation and the organizational performance of banks? *European Journal of Social Sciences*, 20(1), 28–46.

Anand, G. and Kodali, R. (2009). Development of a framework for lean manufacturing systems. *International Journal of Services and Operations Management*, 5(5), 687–716.

Ankomah, E. N., Baiden, B. K. and Ofori-Kuragu J. K. (2015). Lean techniques approaches to managing Ghanaian contractor supply chains. *International Journal of Construction Engineering and Management*, 4(3), 87–94.

Antunes, R., Gonzalez, V. A. and Walsh, K. (2016). Quicker reaction, lower variability: The effect of transient time in flow variability of project-driven production. *Proceedings of the 24th Annual Conference of the International Group for Lean Construction*. 21–23 July. Boston, MA. Section 1. pp. 73–82. Available at: www.iglc.net

Anvuur, A., Kumaraswamy, M. and Male, S. (2006). Taking forward public procurement reforms in Ghana. *CIB W107 Construction in Developing Economies International Symposium. "Construction in Developing Economies: New Issues and Challenges"*. 18–20 January. Santiago, Chile.

Arroyo, P. and Gonzalez, V. (2016). Rethinking waste definition to account for environmental and social impacts. *Proceedings of the 24th Annual Conference of the International Group for Lean Construction*. 20–22 July. Boston, MA. Section 10. pp. 13–22.

Atuahene, B. T. (2016). *Organizational culture in the Ghanaian construction industry*. A thesis submitted to the Department of Building Technology, College of Art and Built Environment, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana, in partial fulfilment of the requirements for the degree of Master of Philosophy.

Ayarkwa, J., Agyekum, K., Adinyira, E. and Osei-Asibey, D. (2012). Perspectives for the implementation of lean construction in the Ghanaian construction industry. *Journal of Construction Project Management and Innovation*, 2(2), 345–359.

Azharul, K. and Arif-Uz-Zaman, K. (2013). A methodology for effective implementation of lean strategies and its performance evaluation in manufacturing organizations. *Business Process Management Journal*, 19(1), 169–196.

Barbosa, G., Andrade, F., Biotto, C. and Mota, B. (2013). Heijunka system to level telescopic forklift activities using tablets in construction site. *Proceedings of the*

21st Annual Conference of the International Group for Lean Construction (IGLC). Fortaleza, Brazil.

Bauchet, J. and Morduch, J. (2013). Is micro too small? Microcredit vs. SME finance. *World Development*, 43, 288–297.

Bhamu, J. and Sangwan, K. S. (2014). Lean manufacturing: Literature review and research issues. *International Journal of Operations & Production Management*, 34(7), 876–940.

Biotto, C., Mota, B., Araújo, L., Barbosa, G. and Andrade, F. (2014). Adapted use of andon in a horizontal residential construction project. *Proceedings of the 22nd Annual Conference of the International Group for Lean Construction (IGLC)*. Oslo, Norway.

Bølviken, T. and Koskela, L. (2016). Why hasn't waste reduction conquered construction? *Proceedings of the 24th Annual Conference of the International Group for Lean Construction*. Boston, MA. Section 1. pp. 3– 12.

Covarrubias, A., Mourgues, C. and Arroyo, P. (2016). VSM for improving the certificate of occupancy process in real estate projects – A Chilean case study. *Proceedings of the 24th Annual Conference of the International Group for Lean Construction*. Boston, MA. Section 4. pp. 123–132. Available at: www.iglc.net

Dahlgaard, J. J. and Dahlgaard-Park, S. M. (2006). Lean production, six sigma quality, TQM and company culture. *The TQM Magazine*, 18(3), 263–281.

Dave, B., Seppänen, O. and Modrich, R.-U. (2016). Modeling information flows between Last Planner and Location Based Management System. *Proceedings of the 24th Annual Conference of the International Group for Lean Construction*. Boston, MA. Section 6. pp. 63–72. Available at: www.iglc.net

Emuze, F. and Ungerer, H. (2014). Change in South Africa construction: Lessons from lean thinking. In: Kalsaas, B.T., Koskela, L. and Saurin, T.A. *22nd Annual Conference of the International Group for Lean Construction*. Oslo, Norway. 25–27 June. pp. 1121–1131.

Frandson, A. G., Seppänen, O. and Tommelein, I. D. (2015). Comparison between Location Based Management and Takt Time Planning. *Proceedings of the 23rd Annual Conference of the International Group for Lean Construction*. 28–31 July. Perth, Australia. pp. 3–12. Available at: www.iglc.net

Fuenzalida, C., Fischer, B., Arroyo, P. and Salvarierra, J. L. (2016). Evaluating environmental impacts of construction operation before and after the implementation of lean tools. *Proceedings of the 24th Annual Conference of the International Group for Lean Construction*. Boston, MA. Section 10. pp. 3–12.

Golicic, S. L. and Medland, S. S. (2007). Size might matter: A case study of lean implementation in an SME. *Proceedings of the Society for Marketing Advances*. Kuala Lumpur, Malaysia: Society for Marketing Advances. pp. 261–264.

Gyadu-Asiedu, W. (2009). *Assessing construction project performance in Ghana: Modelling practitioners' and clients' perspectives*. A thesis submitted to the

Eindhoven University of Technology, Eindhoven, The Netherlands, for the award of doctorate degree.

Harris, B. N. and Alves, T. C. L. (2016). Building information modeling: A report from the field. *Proceedings of the 24th Annual Conference of the International Group for Lean Construction*. Boston, MA. Section 5. pp. 13–22. Available at: www.iglc.net

Herrala, M. E., Pekuri, A. and Aapaoja, A. (2012). How Do You Understand Lean? In: Tommelein, I. D. and Pasquire, C. L. *20th Annual Conference of the International Group for Lean Construction*. San Diego, CA. 18–20 July.

Hicham, H., Taoufiq, C. and Aziz, S. (2016). Last Planner® System: Implementation in a Moroccan construction project. *Proceedings of the 24th Annual Conference of the International Group for Lean Construction*. Boston, MA. Section 6. pp. 193–202. Available at: www.iglc.net

Hirota, E. H. and Formoso, C. T. (2001). Barriers to management innovations: Communicating meanings. *Proceedings of the 9th Annual Conference of the International Group for Lean Construction*. Singapore, Singapore.

Jang, J. W. and Kim, Y.-W. (2007). Using the kanban for construction production and safety control. *Proceedings of the 15th Annual Conference of the International Group for Lean Construction (IGLC)*. East Lansing, MI.

Kemmer, S. L., Saraiva, M. A., Heineck, L. F. M., Pacheco, A. V. L., Novaes, M. de V., Mourão, C. A. M. A. and Moreira, L. C. R. (2006). The use of andon in high rise building. *Proceedings of the 14th Annual Conference of the International Group for Lean Construction*. Santiago, Chile.

Kheni, N. A. (2008). *Impact of health and safety management on safety performance of small and medium-sized construction businesses in Ghana*. A thesis submitted to Loughborough University, Loughborough, UK, in partial fulfilment of the requirements for the award of the degree of Doctor of Philosophy.

Knotten, V., Svalestuen, F., Aslesen, S. and Dammerud, H. (2014). Integrated methodology for design management – A research project to improve design management for the AEC industry in Norway. *Proceedings of the 22nd Annual Conference of the International Group for Lean Construction*. Oslo, Norway.

Korb, S. (2016). "Respect for people" and lean construction: Has the boat been missed? *Proceedings of the 24th Annual Conference of the International Group for Lean Construction*. Boston, MA. Section 1. pp. 43–52. Available at: www.iglc.net

Koskela, L. (2015). Where rhetoric and lean meet. *Proceedings of the 23rd Annual Conference of the International Group for Lean Construction*. Perth, Australia. 29–31 July. pp. 527–535. Available at: www.iglc.net

Kpamma, Z. E., Adjei-Kumi, T., Ayarkwa, J. and Adinyira, E. (2014). Enhancing user-involvement through a multi-criteria decision aid: A lean design research agenda. *Proceedings of the 22nd Annual Conference of the International Group for Lean Construction*. Oslo, Norway.

Liker, J. (2004). *The Toyota Way: 14 management principles from the world's greatest manufacturer*. New York: McGraw-Hill.

Liker, J. K. and Meier, D. (2006). *The Toyota Way fieldbook: A practical guide for implementing Toyota's 4Ps*. New York: McGraw-Hill.

Mazanai, M. (2012). Impact of just-in-time (JIT) inventory system on efficiency, quality and flexibility among manufacturing sector, small and medium enterprise (SMEs) in South Africa. *African Journal of Business Management*, 6(17), 5786–5791.

Miller, C. J. M., Packham, G. A. and Thomas, B. C. (2002). Harmonization between main contractors and subcontractors: A prerequisite for lean construction? *Journal of Construction Research*, 3(1), 67–82.

Moyano-Fuentes, J. and Sacristán-Díaz, M. (2012). Learning on lean: A review of thinking and research. *International Journal of Operations & Production Management*, 32(5), 551–582.

Murguía, D., Brioso, X. and Pimentel, A. (2016). Applying lean techniques to improve performance in the finishing phase of a residential building. *Proceedings of the 24th Annual Conference of the International Group for Lean Construction*. Boston, MA. Section 2. pp. 43–52. Available at: www.iglc.net

Ofori, G. and Toor, S. R. (2012). Leadership development for construction SMEs. *Working paper proceedings of the Engineering Project Organizations Conference*. Rheden, The Netherlands. 10–12 July.

Panizzolo, R., Garengo, P., Sharma, M. K. and Gore, A. (2012). Lean manufacturing in developing countries: Evidence from Indian SMEs. *Production Planning & Control: The Management of Operations*, 23(10-11), 769–788.

Rose, A. N. M., Deros, B. Md. and Rahman, M. N. Ab. (2013). Lean manufacturing perceptions and actual practice among Malaysian SMEs in automotive industry. *International Journal of Automotive and Mechanical Engineering*, 7, 820–829.

Rose, A. N. M., Deros, B. Md, Rahman, M. N. Ab. and Nordin, N. (2011). Lean manufacturing best practices in SMEs. *Proceedings of the International Conference on Industrial Engineering and Operations Management (IEOM)*. Kuala Lumpur, Malaysia: IEOM Research Solutions. pp. 22–24.

Rossiti, I. S. M., Serra, S. M. B. and Lorenzon, I. A. (2016). Impacts of lean office applications in the supply sector of a construction company. *Proceedings of the 24th Annual Conference of the International Group for Lean Construction*. Boston, MA. Section 8. pp. 63–72. Available at: www.iglc.net

Rybkowski, Z. K., Munankami, M., Shepley, M. M. and Fernández-Solis, J. L. (2016). Development and testing of a lean simulation to illustrate key principles of Target Value Design: A first run study. *Proceedings of the 24th Annual Conference of the International Group for Lean Construction*. Boston, MA. Section 4. pp. 133–142. Available at: www.iglc.net

Salem, O., Solomon, J., Genaidy, A. and Luegring, M. (2005). Site implementation and assessment of lean construction techniques. *Lean Construction Journal*, 2(2), 1–21.

Shah, R. and Ward, P. T. (2003). Lean manufacturing: Context, practice bundles, and performance. *Journal of Operations Management*, 21(2), 129–149.

Shang, G. (2013). *The Toyota Way model: An implementation framework for large Chinese construction firms*. A thesis submitted to the Department of Building, National University of Singapore, for the degree of Doctor of Philosophy.

Taleghani, M. (2010). Success and failure issues to lead lean manufacturing implementation. *World Academy of Science, Engineering and Technology, 6*, 615–618.

Tezel, A., Aziz, Z., Koskela, L. and Tzortzopoulos, P. (2016). Benefits of visual management in the transportation sector. *Proceedings of the 24th Annual Conference of the International Group for Lean Construction*. Boston, MA. Section 6. pp. 123–132. Available at: www.iglc.net

Toledo, M., Olivares, K. and González, V. (2016). Exploration of a Lean-BIM planning framework: A Last Planner System and BIM-based case study. *Proceedings of the 24th Annual Conference of the International Group for Lean Construction*. Boston, MA. Section 5. pp. 3–12. Available at: www.iglc.net

Tommelein I. D. (2008). "Poka yoke" or quality by mistake proofing design and construction systems. *Proceedings of the 16th Annual Conference of the International Group for Lean Construction*. Manchester, UK.

Womack, J. P., Jones, D. T. and Roos, D. (1990). *The machine that changed the world: The story of lean production*. New York: Harper Perennial.

THE STATE OF ADOPTION OF LEAN CONSTRUCTION IN THE TANZANIAN CONSTRUCTION INDUSTRY

Nyamagere Gladys SOSPETER[1] and Geraldine John KIKWASI[2]

[1]Lecturer, Department of Building Economics, Ardhi University, Dar es Salaam, Tanzania, Email: nyamagere@yahoo.com
[2]Senior lecturer, Department of Building Economics, Ardhi University, Dar es Salaam, Tanzania, Email: gkikwasi@aru.ac.tz

ABSTRACT

Lean has been able to minimise waste, improve quality, and increase value for money in the construction industry. However, the extent of adoption of lean construction concepts is yet to be determined for the Tanzanian construction industry. The purpose of this study is to investigate adoption of lean construction concepts, and to determine the barriers to implementation of such concepts. Data were collected from practising consulting and contracting firms, using self-administered questionnaires. Forty-six of the 60 questionnaires distributed were completed and returned, and they were analysed using the Statistical Package for the Social Sciences (SPSS). The findings indicate that the lean concept adopted in the Tanzanian construction industry is teamwork. It was consistently found that the main barriers to adoption of lean construction in the Tanzanian construction industry are a lack of technical skills and inadequate design and client information. Generally, there is a low rate of adoption of lean construction in Tanzania, as most of the listed concepts are not yet sufficiently recognised by the respondents. The study recommends promoting lean construction concepts, and creating awareness of such concepts, through continuous training, open communication channels, and an embracing of lean by project participants and construction-related associations. This paper makes a contribution to the body of knowledge on the subject of lean construction adoption within the previously unexplored context of Tanzania.

Keywords: lean construction, concepts, barriers, benefits, principles

INTRODUCTION

The Tanzanian construction industry contributes to national growth, through the gross domestic product (GDP), gross fixed capital formation, creation of employment opportunities, and industrial productivity. Despite this significant contribution, the industry faces a number of performance challenges, such as inadequate funding, a lack of technical skills, and bureaucratic procurement procedures, most of which have been

explained in reports and studies by the NBS (2013), UNESCO (2010), and Muhegi (2007). For a long time, construction industries in developing countries have continued to perform inadequately (ILO, 2003; Rwelamila, 2009). Projects are delivered beyond the expected budget and duration, there is a high incidence of waste, and quality is low (ILO, 2003). The inadequate performance of the construction industry is linked to inappropriate approaches to projects, and non-use of lean construction. Lean construction involves a continuous and methodical pursuit of delivering value for customers through minimising waste and improving quality and efficiency in the construction industry (Sniegowski and Royer, 2012). Lean construction is a concept that has been introduced extensively in developed countries, and in some developing countries, and its application within the industry is reported to have many benefits (Sniegowski and Royer; 2012; Ballard and Howell, 2003). Dulaimi and Tanamas (2001) and Gleeson and Townend (2007) point out that lean construction has realised significant improvements, particularly on complex, uncertain, or quick projects.

Although lean construction concepts have recently received attention as a modern way of improving construction performance and labour productivity, the industry is slow in taking up lean concepts (Matias and Cachadinha, 2010; Alinaitwe, 2009). The slow uptake of lean construction is linked to a number of barriers. Alinaitwe (2009), Matias and Cachadinha (2010), Bashir et al. (2015), Ayarkwa et al. (2011), Sarhan and Fox (2013), Shang and Pheng (2014), Wandahl (2014), Devaki and Jayanthi (2014), Olamilokun (2015), and Aigbavboa et al. (2016) have determined the barriers to implementation of lean construction in both developed and emerging economies. These barriers have been categorised into technical barriers, managerial barriers, barriers related to human attitudes, financial barriers, barriers related to the process of lean construction, government barriers, and educational barriers.

Generally, lean construction practice is yet to be appreciated in the construction industry, in both developed and developing countries. Lean construction practice, and barriers to its implementation in the construction industry, is an area of the industry that remains unexplored in Tanzania. This research seeks to shed light on this area. To determine the state of adoption of lean construction in Tanzania, a descriptive type of research was adopted. Data were collected using self-administered questionnaires and a literature review. Data were analysed by using frequencies, descriptive statistics, and independent-samples t-test features of the SPSS. This paper reports on the state of lean construction practice in Tanzania, and it reveals the barriers to its implementation. The findings of this study are intended to initiate debate on lean construction practice among researchers in construction management in the country. In addition, the paper documents previous work on adoption of lean concepts, and barriers to their implementation, and it provides a description of how the research was done, an analysis and discussion of the findings, and conclusions and recommendations.

AN OVERVIEW OF THE TANZANIAN CONSTRUCTION INDUSTRY

The construction industry in Tanzania, as in many other countries, contributes significantly to national growth, through the gross domestic product (GDP), gross fixed capital formation, creation of employment opportunities, and industrial productivity. According to the United Republic of Tanzania (URT) (2013), in volume terms, the construction industry accounted for an average of 6.8% of GDP in the period 2003–2010. In addition, URT (2013) data indicates that in terms of real output performance, growth of the construction sector was about 10.5% in 2010, and that this sector showed the highest growth rate after the telecommunications sector. The URT (2011) reveals that the contribution of the industry to gross fixed capital formation was over 50% in 2011. Similarly, the URT (2015), through the Integrated Labour Force Survey (ILFS) Analytical Report, discloses that in 2014 the construction industry employed 2.1% of the labour force in the formal sector, and 6.2% in the informal sector.

Despite its recorded performance, the industry still faces a number of performance challenges. These challenges, discussed in reports and studies by the URT (2013), UNESCO (2010), and Muhegi (2007), can be summarised as follows:

a) inadequate institutional coordination of planning between the construction industry and other sectors of the economy;
b) inadequate fiscal and non-fiscal incentives and motivation among workers;
c) insufficient skilled, qualified, and experienced personnel;
d) inadequate funding;
e) a lack of professional ethics, including corruption among some of the stakeholders;
f) use of inappropriate technologies that do not meet required construction standards;
g) competition from imported building materials;
h) transport bottlenecks in the distribution of construction materials;
i) inadequate management skills;
j) stiff competition/access to work opportunities, and
k) bureaucratic procurement procedures.

The URT (2010) discloses that there are three main extended problems to road projects. These are: road projects are not completed within the agreed-upon time; additional but avoidable costs are incurred; and there are weaknesses in the quality control system, which leads to early wear and tear of constructed roads. Some of these challenges can be minimised by adoption of lean construction in the industry. Nevertheless, the government has been putting in place measures to address these challenges. These measures include (Muhegi, 2007; URT, 2015):

a) restructuring of tender boards, to ensure separation of authority, by letting technocrats deal with the technical aspects, and letting politicians deal with ensuring checks and balances;
b) exemption of VAT and import duty on all generic construction equipment, as an incentive for contractors to procure equipment;

c) a significant number of affirmative policies in procurement, such as preference schemes, and adoption of bid declaration instead of bid security;
d) a review of the Public Procurement Act, 2004, and its Regulations, 2005, and replacement of it with the Public Procurement Act, 2011, and its Regulations, 2013, so as to eliminate bureaucratic procurement procedures and enhance transparency, and
e) an increase in the government's development budget, from 26% in 2015/16 to 40% in 2016/17 (URT, 2015).

LEAN IN THE CONSTRUCTION INDUSTRY

Lean construction principles

Womack and Jones (1996), and Bashir et al. (2015) identify and elaborate on five fundamental principles: value, value stream, flow, pull, and perfection. Value is ultimately defined by customer needs, through tools such as value management, quality function deployment, and simulation, so as to deliver client satisfaction (Gleeson and Townsend, 2007). It is suggested that after establishing the real value of a product or service, as determined by the final customer of an economic process, a lean transformation process will then seek to eliminate all wasted effort, materials, time, space, etc. from the set of all activities and operations (Lim, 2008; Wu and Wang, 2016). A product focus is essential, as it enables long-term dialogue to be started, while dealing with the nature of value, and how the product delivers it. In the end, the client requires a building that suits their purposes and provides value for money (Womack and Jones, 1996; Lim, 2008).

Value stream identifies all those steps required to make a product, for example the way value is realised, and it establishes when and how decisions are to be made. The purpose of the important technique of value stream is to understand how value is built into the building product, from the client's perspective. Value stream maps can be understood by identifying what action releases work to the next operation. Mapping not only brings choices to the surface, but also raises the possibility of maximising performance during construction. Under normal circumstances, maps are prepared at the project level, and are then deconstructed, to better understand how the design of planning, logistics, and operation systems works together to support customer value (Emuze and Saurin, 2016; Koskela, 1992). At strategic level, it offers a perspective on defining what is to be done to bring that product or service to market. Furthermore, the idea of identifying value streams such as the structure and the building envelope, and considering how these systems are to be designed, supplied, and constructed, offers a different way of organising for construction. Koskela (1992) and Wu and Wang (2016) believe that lean construction should be focused on value, rather than on cost only.

Flows are characterised by time, cost, and value. Resources (labour, materials, and construction equipment) and information flows are the basic units of analysis in lean construction (LC) (Womack and Jones, 1996; Lim, 2008). The literature shows that

there are controllable and uncontrollable flows (Womack and Jones, 1996; Lim, 2008). Controllable flows are those within the control of the manager, such as materials from the warehouse, or instructions from management. Uncontrollable flows are those beyond the control of the site manager/engineer, such as suppliers' provisions of resources, and design information. Importantly, flow is expected to achieve a holistic route through the means by which a product is developed (Emuze and Saurin, 2016; Gleeson and Townsend, 2007). In this case, LC works to eliminate places where value-adding work on materials or information is interrupted. Figure 1 illustrates the five principles that need to be considered when implementing lean construction.

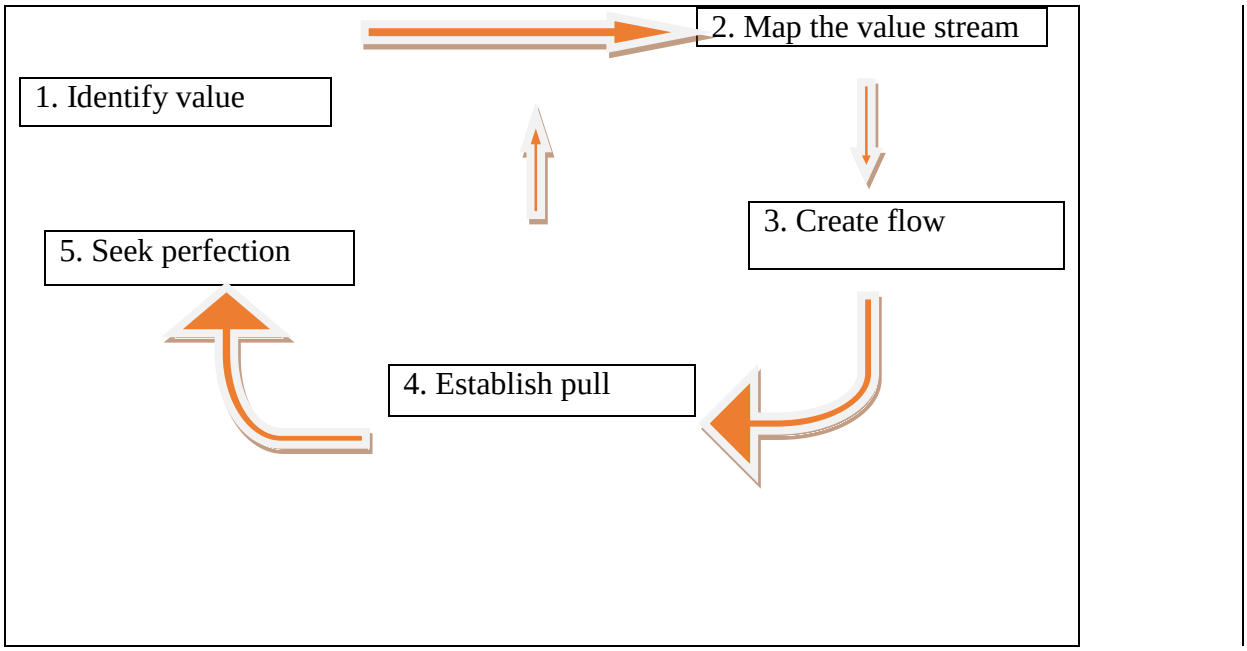

Figure 1: Lean construction principles (Source: Lean Enterprise Institute, 2009)

Each of the stages is necessary, and once one stage is implemented, impacts are noticed. Thus, lean principles can only be applied fully and effectively in the construction industry by focusing on improving the whole process, ensuring integration among project team members, and increasing transparency, particularly on issues related to waste elimination. As depicted in Figure 1, lean construction is a way of designing production systems so as to minimise waste of materials, time, and effort, in order to generate the maximum possible amount of value. Lean construction involves using the same principles as lean production, in order to reduce waste and increase productivity and effectiveness in construction work (Aziz and Hafez, 2013; Wu and Wang, 2016). The most important determinants of construction are supposed to be workflow reliability and labour flow, but lean construction has challenged the traditional view of the project

as transformation, and it embraces the concept of flow and value generation. It also shares the same objectives as lean production, namely cycle time reduction, elimination of waste, and variability reduction. Continuous improvement, pull production control, and continuous flow have long been the direction in implementation of lean construction.

Incorporating lean construction in the construction industry

Lean construction has a number of benefits; for this reason, it is important for stakeholders to incorporate LC in the construction process. Koskela (1992) asserts that there are many benefits when implementing LC in construction projects. The greatest benefit is that construction companies can reduce construction costs, by using the exact quantity of materials required, and by reducing waste. LC also produces better results in complex, uncertain, or quick projects (Salem et al., 2005). Table 1 lists the benefits that are claimed for implementation of lean construction in the construction industry in several emerging economies.

Table 1: Benefits of lean construction

Benefit	Project type	Country
It leads to a reduction in expected total construction cost and time.	Residential buildings	Brazil
It dramatically improves worker safety and customer satisfaction, and it increases value and reduces cost.	Housing construction	Denmark
It leads to a reduction in cycle time.	Building projects	USA
It results in improved structures, and it promotes discipline in planning.	Building projects	United Kingdom
It results in improved reliability in planning and executing projects.	39 low-rise buildings, 15 high-rise buildings, 11 heavy-construction and 12 light-industrial projects	Chile
It leads to improved planning and workflow reliability.	Heavy civil construction projects	Korea
It increases process reliability, it reduces total time, and it improves quality.	Residential buildings	Canada

It improves the supply system and the flow of the construction process, and it minimises waste.	Structural steel industrial houses	USA
It leads to a reduction in project duration and cost, and it improves communication flow.	Industrial houses	USA

(Sources: Mossman, 2009; Sniegowski and Royer, 2012)

There are a number of key concepts of LC that can be implemented by stakeholders. Lean concepts are listed by Harris and McCaffer (1997) (cited in Alinaitwe, 2009) and Marhani et al. (2013) as total quality management (TQM), Last Planner System (LPS), business process re-engineering (BPR), concurrent engineering (CE), product circles (PCs), teamwork, and value-based management (VBM). In addition, Alinaitwe (2009) lists other concepts, such as just-in-time (JIT), increased visualisation, and the 5S process. Most of these concepts are interrelated, and it is important to understand all the key concepts of LC, which may improve performance, while minimising construction waste. Figure 2 presents the key concepts by Marhani et al. (2013), who argue that most LC concepts are interrelated, and that it is therefore important for stakeholders to be responsible and choose the best LC concepts that can be implemented in their construction sites.

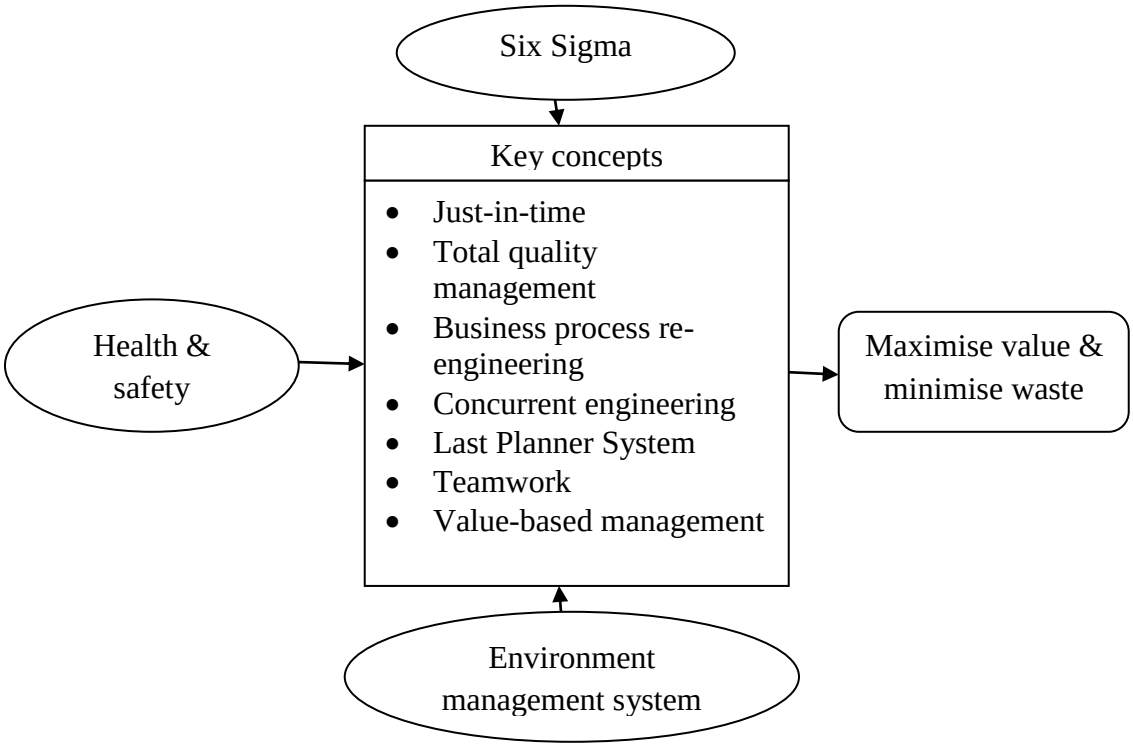

Figure 2: Key concepts (Source: Marhani et al., 2013)

The lean construction concepts assessed in this study have been defined by various authors. The definitions and explanations presented in Table 2 serve to enable a basic understanding of the lean concepts assessed.

Table 2: Operational definitions of LC concepts

Concept	**Explanation/definition of LC concept**	**Source**
Just-in-time (JIT)	JIT is highly dependent on high quality and reduced set-up times, where raw materials and components reach production operation in the desired quantities, and when needed, not before.	Ballard and Howell (1997)
Total quality management (TQM)	TQM is a philosophy that involves every organisation in the industry, in an effort to improve performance. It permeates every aspect of a company, and it makes quality a strategic objective.	Arditi and Gunaydin (1997)
Business process re-engineering	BPR stresses a radical reconfiguration of work processes and tasks, especially with	Davenport and Short (1990)

(BPR)	respect to information technology as an enabler.	
Concurrent engineering (CE)	CE is a design process where all life cycle phases of a product are considered simultaneously, from the conceptual stage through to the detailed design stage.	Kusiak (1993)
Last Planner System	The Last Planner refers to the last individual, typically the foreman, who is able to ensure predictable workflow downstream.	Fernandez-Solis et al. (2013)
Teamwork	Teamwork is working together in a group, where every member strives to fulfil their obligations.	Aziz and Hafez (2013)
Value-based management (VBM)	VBM is an extension of value management, and it applies process values as a means for achieving higher product values.	Wandahl and Bejder (2003)
Increased visualisation	Increased visualisation involves use of computer-aided visualisation in design (3D), planning (4D), and the construction process (3D).	Sacks et al. (2009)
Product life cycles (PCs)	Product life cycles involve a holistic view of the entire product life cycle, identification of suitable timing, and a systematic approach for lean production system design and its implementation.	Yang (2014)

Barriers to successful implementation of lean construction

Different authors have identified different barriers to successful implementation of lean construction. These barriers are related to fragmentation and subcontracting, procurement and contracts, culture and human attitude issues, the design/construction dichotomy, and educational issues. Alanaitwe (2009) determined the top 10 barriers that are easiest to overcome. Sniegowski and Royer (2012) state that many similar factors in the construction industry of both developed and developing countries act as obstacles to adoption of LC concepts. Similarly, Mossman (2009), Alanaitwe (2009), and Abdelhamid (2007) point out that in both developed and developing countries, fragmentation and subcontracting in construction hinder project participants from cooperating and learning together. Sniegowski and Royer (2012) explain that any form of procurement that tends to delegate design work to an external designer, without any follow-up or incorporation, separates the design work from the construction process, and therefore misses the lean aim of collaboration and integration. Gleeson and Townend (2007) point out that forms of contracts allow one party to impose power over another, an adversarial relationship that creates transaction costs which are considered waste, thus contradicting the philosophy of lean.

Abdelhamid (2007), Seymour et al. (1998), and Gleeson and Townend (2007) agree that applying lean thinking principles in the construction industry requires a new way of thinking about the entire process, in order to remove waste, create continuous flow, and radically enhance value to the customer. However, the culture of the construction industry is known to be opportunistic, prone to conflict, and resistant to change, which limits the lean process (Sniegowski and Royer, 2012). Obstacles related to culture and human issues have been documented as a lack of commitment, inability to work in a group, lack of a production process, cultural issues in getting subcontractors and workers to adopt the methodology in a comprehensive way, fear of taking risks, the wrong attitude to change, not viewing housekeeping as a continuous effort, a lack of team spirit among professionals, overzealous champions, dependency, a lack of incentives and motivation, a lack of trust, and fear of blame and contractual disputes. Another barrier to successful implementation of lean construction is the tendency of construction firms to apply traditional management concepts, as opposed to productivity and quality initiatives (Abdelhamid, 2007). According to Matias and Cachadinha (2010), it seems that commercial pressure to do the deal takes precedence over production issues.

Successful implementation of LC requires adequate funding to provide the relevant tools and equipment, adequate wages for professionals, incentives and reward systems, investment in training and development programmes, and use of a lean specialist, to provide guidance to both employer and employees during the initial implementation. Bashir et al. (2015) and Mossman (2009) have revealed some common financial barriers that need to be carefully addressed. These include inflation, inadequate funding of projects, unstable markets for construction, a lack of basic social amenities required for facilitating LC implementation, a lack of incentives and motivation, poor

remuneration for professionals, unwillingness by some companies to invest additional funds to provide training for their workers above and beyond the minimum legislative requirements, and a lack of commitment and support from top management. Successful implementation of LC or any new innovative strategy needs to be supported by top management. Top management has to provide sufficient time and resources to develop an effective plan and manage changes arising from the implementation process (Bashir et al., 2015). The benefits for top management of implementing LC are clear, namely increased productivity, and a reduction in time and number of accidents (Mossman, 2009). Design and adequate planning contribute significantly to the lean construction process. Any ignorance of the importance of these could have disastrous consequences in terms of wasted time, unnecessary costs, and prolonging of the overall process (Matias and Cachadinha, 2010; Sniegowski and Royer, 2012). There have been several attempts by researchers, academics, practitioners, and professional bodies in the construction industry to provide awareness and guidance regarding LC, and in some countries it seems that educational barriers could pose a significant threat to sustainable implementation of LC (Bashir et al., 2015; Emuze and Saurin, 2016). A lack of customer-focused and process-based performance measurement systems has been cited by Sniegowski and Royer (2012) and Alarcón and Serpell (1996) as barriers to implementation of lean construction. Marhani et al. (2013) and Olamilokun (2015) categorise barriers to implementation of lean construction as managerial barriers, technical barriers, human attitude barriers, barriers in the process of LC, educational barriers, government barriers, and financial barriers. Table 3 below summarises the classification of barriers to implementation of lean construction as technical barriers, managerial barriers, and human attitude barriers, as identified in earlier studies. Based on the literature, Table 3 reveals that barriers to implementation of lean construction in emerging economies (Alanaitwe, 2009; Ayarkwa et al. 2011) are mainly technical or managerial. By contrast, in developed countries (Sarhan and Fox, 2013; Bashir et al., 2015), barriers are technical, particularly in terms of inadequate lean construction knowledge, and related to human attitudes. However, barriers that remain common to both types of economies (Alanaitwe, 2009; Bashiri et al., 2015; Sarhan and Fox, 2013; Ayarkwa et al., 2011; Wandahl, 2014; Shang and Pheng, 2014; Devaki and Jayanthi, 2014; Olamilokun, 2015; Aigbavboa et al., 2016) are technical barriers and managerial barriers.

Table 3: Categories of barriers to implementation of LC

Source	Type of barrier		
	Technical	**Managerial**	**Human attitudes**
Matias and Cachadinha (2010)	Lack of technical skills, inadequate training, poor understanding and awareness, poor teamwork skills, illiteracy, and computer illiteracy		Ignorance of human resource management and development
Olamilokun (2015)	Inadequate exposure to the requirements for lean implementation, inaccurate and incomplete designs	Inadequate pre-planning	Corruption, misconceptions about lean concepts
Ayarkwa et al. (2011)	Lack of technical capabilities, lack of financial resources	Lack of proper planning and control, lack of teamwork, poor project management, poor communication between parties	
Sarhan and Fox (2013)	Lack of adequate lean awareness and understanding	Lack of commitment from top management	Cultural and human attitudinal issues
Alanaitwe (2009)	Lack of buildable designs, not using standard components, lack of project team skills	Lack of participative management style for the workforce, not having compatible management leadership, lack of steady work engagement, lack of communication within teams, not understanding the needs of customers, i.e. internal and external needs, and not	

		having a well-defined focus for the team	
Shang and Pheng (2014)	Insufficient management skills, multi-layer subcontracting	Lack of a long-term lean philosophy, lack of support from top management	Absence of a lean culture in the organisation
Wandahl (2014)	Lack of knowledge	Lack of commitment, cooperation, and communication	
Aigbavboa et al. (2016)	Extensive use of unskilled labour, the fragmented nature of the industry	Inadequate pre-planning, poor communication	Human attitudes towards change, lack of interest from clients
Devaki and Jayanthi (2014)	Lack of exposure to the need to adopt lean construction, a tendency to apply traditional management concepts	Uncertainty in the supply chain, lack of commitment from top management, a non-participative management style for the workforce	Culture and human attitudinal issues
Bashir et al. (2015)	Lack of lean knowledge, old-school thinkers not seeing the long-term goal, an old-school mentality, the high cost of implementation, the long implementation time	Lack of cooperation, lack of long-term forecasting and investment, lack of management support, and high expectations from management	A change in attitude and thinking is needed, and there are misconceptions about lean

METHODOLOGY

This is a descriptive type of research. According to Kumar (2011), this type of research attempts to systematically describe a situation, problem, phenomenon, service, or

programme, or to provide information. The main purpose of the study was to describe the trends of lean construction adoption in Tanzania. The study population included contractors from class I to class III, and consulting firms in the fields of architecture, engineering, and quantity surveying. The above-mentioned classes of contractors were chosen because it was deemed that they would have relevant expertise in construction, and that reliable data would thus be obtained from these groups. Contractors in Tanzania are registered in seven classes, namely classes I–VII. Class I is the highest class, and class VII is the lowest. The classes are broken down as follows: classes I and II (large contractors), class III (medium contractors), and classes IV–VII (small and emerging contractors). It was expected that the consultant subsample would supplement information obtained from the contractor subsample. Purposive sampling was used to select the respondents, as it was deemed that the respondents have knowledge of lean construction. Another consideration was availability and willingness of respondents to participate in the study. A sample size of 60 respondents was decided on, consisting of 12 architects, 13 quantity surveyors, 15 engineers, and 20 contractors. The selected sample size was such that it was sufficient to set a baseline for further studies on the subject (Oyediran and Akintola, 2011).

A literature review and questionnaires were used to collect data for the study. Previous work on the subject and gaps in the research were determined through a review of the literature. Questionnaires consisted of both open-ended and closed-ended questions that were logically related to the research topic. The content, the structured responses, the wording of the questions, and the question sequence were the same for all respondents. Of the 60 questionnaires distributed, 46 were completed for purposes of analysis, which equates to a response rate of 76.7%.

Data were analysed using the SPSS software package version 20. Descriptive statistics, namely frequencies, descriptive, and a comparison of means (independent-samples t-test), were used. To validate these results, lean construction concepts were extracted from the literature, mainly from Harris and McCaffer (1997) (cited in Alinaitwe, 2009) and Marhani et al. (2013). Respondents were requested to indicate their level of adoption, on a scale from 1 to 5, where 1 represents “No idea”, 2 represents “Not at all”, 3 represents “Used on average”, 4 represents “Used”, and 5 represents “Mostly used”. Similarly, barriers were extracted from the literature, and respondents were requested to agree or disagree, using the response options of 1 (“disagree”), 2 (“agree”), or 3 (“strongly agree”).

ANALYSIS AND DISCUSSION

Respondents’ level of experience

The majority of respondents (67.4%) had experience of more than 5 years working in the construction industry, and the rest (32.6%) had less than 5 years’ experience.

Awareness of lean construction in the Tanzanian construction industry

Figure 3 depicts the level of awareness of lean construction. Only 37% of respondents indicated that they were familiar with lean construction. Thirty-five percent of respondents indicated that they were somewhat familiar with lean construction. Surprisingly, 28% of respondents were not aware of lean construction. This implies that the majority of respondents have little or no knowledge of lean construction. However, the same respondents were able to rank adoption of lean construction concepts and associated barriers, simply because they have knowledge of the concepts as normal practice in construction.

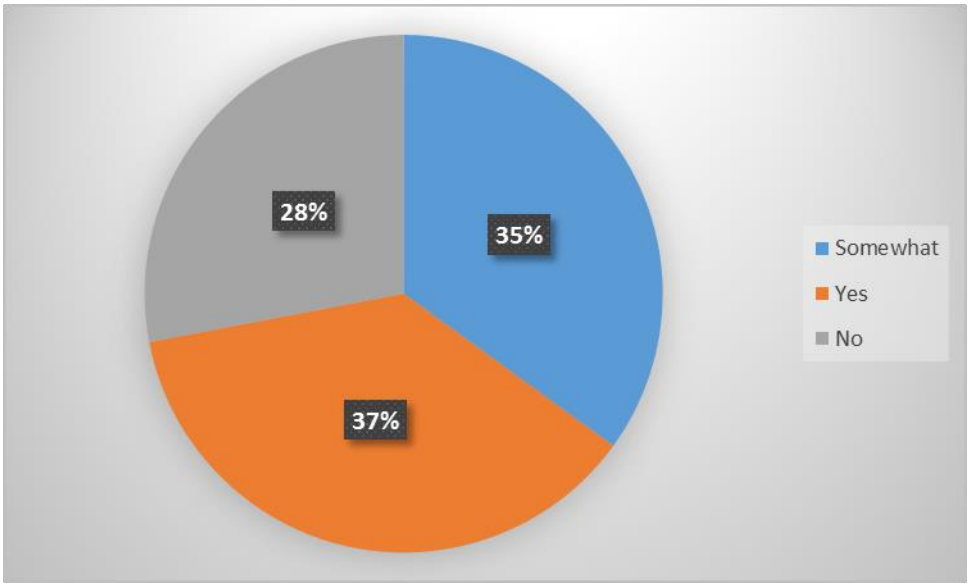

Figure 3: Familiarity with lean construction

Lean construction practice in the construction industry

Table 4 summarises the findings with regard to respondents' use of various lean construction concepts and associated lean concepts. Prior to indicating adoption of lean construction, respondents were to indicate if they had ever been involved in lean construction. Their responses were the same as those for awareness of lean construction, that is, 37% responded "yes", 35% responded "no", and 28% responded "somewhat". The results indicate that only total quality management (TQM), teamwork, and value-based management (VBM) had mean scores of $3.60 \leq 2.5$. The other concepts are almost not used at all. It should be noted that total quality management (TQM) and value-based management (VBM) are not lean concepts, but are associated lean concepts. The only remaining lean concept, namely teamwork, and the two associated concepts, namely total quality management and value-based management, are thus the only concepts used in lean construction practice in Tanzania. TQM and VBM are concepts that were mentioned by Harris and McCaffer (1997) (cited in Alinaitwe, 2009) and Marhani et al.

(2013). The conclusion that can thus be drawn is that Tanzania relies only on the lean concept of teamwork to implement lean construction. Teamwork is working together in a group, where every member strives to fulfil their obligations. Teamwork is a tradition in the construction industry, as each project brings together people from different backgrounds to work together. However, to realise this endeavour, project team members need to focus on their respective responsibilities, so as to achieve one goal, namely to deliver the project in line with predetermined objectives. While a number of studies (Harris and McCaffer, 1997, cited in Alinaitwe, 2009; Marhani et al., 2013) identify teamwork as a concept of lean construction, teamwork and other concepts have also received negative criticism. Green (1999) explains that the concepts of quality and teamwork have been blamed for translating into control, exploitation, and surveillance of the workforce. This means that while teamwork is one of the concepts in adoption of lean construction, its usefulness can be questioned if it is used in such a way that the workforce feels that they are being oppressed, or that they are working in a stressful environment.

Table 4: Use of lean construction concepts in the construction industry

Lean construction concept	N	Mean	SD	Ranking
Total quality management (TQM)	10	3.60	2.319	1
Teamwork	45	3.40	1.468	2
Value-based management (VBM)	10	2.70	1.418	3
Product life cycles (PCs)	45	2.47	1.307	4
Just-in-time	9	2.44	1.236	5
Concurrent engineering (CE)	44	2.16	.987	6
Business process re-engineering (BPR)	45	2.04	1.086	7
Last Planner System (LPS)	45	2.02	1.215	8
Increased visualisation	8	2.00	1.414	9

Experience and lean construction involvement

Table 5 presents a summary of the influence of work experience on involvement in lean construction. Experience was categorised as less experienced (≤ 5 years) or experienced (> 5 years). Using group statistics, the results indicate that with the exception of TQM and PCs, where less experienced respondents have been involved in lean construction, experienced respondents have been slightly more involved in lean construction than have been less experienced respondents. Analysis using the independent-samples t-test reveals that there is no significant difference between experienced and less experienced respondents in involvement in lean construction. This suggests that lean construction in the Tanzanian construction industry is yet to be appreciated. This finding confirms the findings of Matias and Cachadinha (2010) and Alinaitwe (2009) that the construction industry is slow in taking up lean concepts, which is the reason why experienced respondents were not conversant with lean construction concepts. This also implies that

knowledge of lean is limited in the construction industry. A number of studies (Matias and Cachadinha, 2010; Bashir et al., 2015; Sarhan and Fox, 2013; Wandahl, 2014; Devaki and Jayanthi, 2014; Shang and Pheng, 2014; Olamilokun, 2015) have suggested that inadequate lean construction knowledge is a barrier to lean construction implementation.

Table 5: Experience and involvement in lean construction

Concept	Level of experience	N	Mean score	SD	Levene's test for equality of variances	
					F	Sig.
C1	Less experienced	4	4.25	3.403	1.815	.215
	Experienced	6	3.17	1.472		
C2	Less experienced	14	1.79	1.051	2.004	.164
	Experienced	31	2.13	1.284		
C3	Less experienced	14	1.71	.994	.563	.457
	Experienced	31	2.19	1.108		
C4	Less experienced	14	1.86	.949	.009	.925
	Experienced	30	2.30	.988		
C5	Less experienced	4	2.25	1.500	1.165	.316
	Experienced	5	2.60	1.140		
C6	Less experienced	3	1.00	.000	4.820	.071
	Experienced	5	2.60	1.517		
C7	Less experienced	15	2.73	1.438	2.777	.103
	Experienced	30	2.33	1.241		
C8	Less experienced	14	2.93	1.639	.800	.376
	Experienced	31	3.61	1.358		
C9	Less experienced	4	1.25	.500	1.912	.204
	Experienced	6	3.67	.816		

C1=total quality management (TQM), C2=Last Planner System (LPS), C3=business process re-engineering (BPR), C4=concurrent engineering (CE), C5=just-in-time, C6=increased visualisation, C7=product cycles (PCs), C8=teamwork, C9=value-based management (VBM)

Barriers to implementation of lean construction in the Tanzanian construction industry

Table 6 presents a summary of respondents' views on barriers to implementation of lean construction in the Tanzanian construction industry. The results indicate that the respondents agree that all the listed challenges are hindering implementation of lean construction. Some of these challenges have been determined in work by Alinaitwe (2009), Matias and Cachadinha (2010), Bashir et al. (2015), and Mossman (2009). This implies that there are many barriers to implementation of lean construction in Tanzania, but that many more have not been explored, due to a low rate of implementation of lean

concepts. The study by Alinaitwe (2009) identifies the top 10 barriers that are easiest to overcome. Awareness of these barriers could facilitate implementation of lean construction in Tanzania.

Table 6: Barriers to implementation of lean construction

Challenge	N	Mean score	SD	Ranking
Lack of technical skills	45	2.53	.625	1
Inadequate design and client information	45	2.51	.727	2
Inadequate risk management	45	2.44	.693	3
Quality control of materials	45	2.36	.712	4
Lack of project team skills	45	2.22	.670	5
Waste in building projects	45	2.20	.815	6
Delays in delivery of materials	45	2.16	.737	7
Lack of communication within teams	45	2.13	.786	8
Corruption	45	2.11	.885	9
Business management skills	45	2.11	.682	10
Financial resources and equipment	45	2.09	.793	11
Work opportunities	44	2.05	.834	12
Lack of buildable designs	45	2.04	.767	13
Poor wages for professionals	45	2.02	.657	14

CONCLUSION AND RECOMMENDATIONS

Successful implementation of LC or any new innovative strategy requires a spirit of teamwork, and it needs to be supported by top management. Effective teamwork should aim to provide sufficient time and resources to develop an effective plan and manage changes arising from the implementation process. For example, in Tanzania, the majority of projects are delivered under traditional contractual procedures. This type of procurement advocates that design and implementation of design be treated as separate products, and this has led to poor design and client information (Marhani et al., 2013). In the course of undertaking construction activities, this tends to cause conflict between the two phases, and it creates much waste, which can be minimised by having a well-organised team. Furthermore, if the management of the organisation works as a team and learns technical skills from each other, this will obviously facilitate implementation and enforcement of LC.

The findings of this paper shed light on the state of adoption of lean construction concepts in the Tanzanian construction industry. There appear to be several barriers that hinder successful adoption of lean construction. It is necessary that these barriers be understood, so that organisations can determine what improvement efforts should be

taken, and what resources should be allocated. The findings of this study may be used by project participants, professionals, and organisations in the Tanzanian construction industry, so that they can change their mindset and set aside resources for implementing lean construction. Lean construction has a number of benefits for the construction industry. As such, it is of the utmost importance that its key concepts be adopted, so that the industry can make the most of lean construction.

Generally, there is a low rate of application of lean construction in Tanzania, as most of the listed lean construction concepts are not yet sufficiently recognised by the surveyed project participants and professionals. It was noted that teamwork is one lean concept that is used in Tanzania. Barriers to implementation of lean concepts are many, some of which are yet to be identified, but the main ones are lack of technical skills and poor design and client information. Use of teamwork would increase the level of collaboration among stakeholders, as well as awareness of lean concepts. Teamwork may also help some organisations to improve their implementation strategies. Through teamwork, the following could be realised: continuous training, and open communication channels between participants. A desire to "embrace lean" will be essential for future implementation of LC. Higher learning institutions offering construction-related programmes should consider including in their programmes an introduction to LC. The analysis and discussion of the findings presented in this paper provide the foundation for determining the state of adoption of lean in the Tanzanian construction industry. Further research is recommended to identify the factors that lead to successful implementation of lean construction, as well as organisation or implementation plans for smooth adoption of lean construction.

ACKNOWLEDGEMENT

This article was language-edited by a freelance language editor, Anthony Sparg. He has edited several academic journal articles and master's theses in the field of construction management. He has an MA *cum laude* in African Languages (isiXhosa), an MA *cum laude* in Linguistics, and a Higher Diploma in Education.

REFERENCES

Abdelhamid, T. S. (2007). *CMP831: Lean construction principles and methods: Lean construction overview*. Graduate class offering at Michigan State University. Available at: http://www.slideshare.net/tabdelhamid/lean-construction-introduction

Aigbavboa, C., Oke, A. and Momoti, T. (2016). Drivers and barriers of lean construction practice in South African construction industry. *Proceedings of the International Conference on Innovative Production and Construction*. 29–30 September. Perth, Australia. pp. 195–201. Available at: https://ujcontent.uj.ac.za/vital/access/manager/Repository/uj:21132/SOURCE1

Alarcón, L. and Serpell, A. (1996). Performance measuring, benchmarking and modeling of construction projects. *Proceedings of the 5th Annual Conference of the International Group for Lean Construction*. Birmingham, UK.

Alinaitwe, H. M. (2009). Prioritising lean construction barriers in Uganda's construction industry. *Journal of Construction in Developing Countries*, 14(1), 15–30.

Arditi, D. and Gunaydin, H. M. (1997). Total quality management in the construction process. *International Journal of Project Management*, 15(4), 235–243.

Ayarkwa, J., Agyekum, K., Adinyira, E. D. and Osei-Asibey, D. (2011). Barriers to successful implementation of lean construction in the Ghanaian building industry. *Journal of Construction*, 5(1), 3–11. Available at: http://www.asocsa.org/documents/JoC-12Dec-vol5-no1.pdf

Aziz, F. R. and Hafez, M. S. (2013). Applying lean thinking in construction and performance improvement. *Alexandria Engineering Journal*, 52(4), 679–695.

Ballard, G. and Howell, G. 1997. Toward Construction JIT, Lean Construction Journal, pp. 291-300.

Ballard, G. and Howell, G. A. (2003). Competing construction management paradigms. *Proceedings of the 2003 ASCE Construction Research Congress*. 19–21 March. Honolulu, Hawaii. Available at: https://www.leanconstruction.org/media/docs/lcj/V1_N1/LCJ_04_0008.pdf

Bashir, M. A., Suresh, S., Oloke, D. A., Proverbs, D. G. and Gameson, R. (2015). Overcoming the challenges facing lean construction practice in the UK contracting organizations. *International Journal of Architecture, Engineering and Construction*, 4(1), 10–18. Available at: http://www.iasdm.org/journals/index.php/ijaec/article/viewFile/230/200

Davenport, T. H. and Short, J. E. (1990). The new industrial engineering: Information technology and business process redesign. *Sloan Management Review*, 31(4), 11–27.

Devaki, M. P. and Jayanthi, R. (2014). Barriers to implementation of lean principles in the Indian construction industry. *International Journal of Engineering Research & Technology*, 3(5), 1189–1192.

Dulaimi, M. F. and Tanamas, C. (2001). The principles and applications of lean construction in Singapore. *Proceedings of the 9th Annual Conference of the International Group for Lean Construction*. 6–8 August. Singapore, Singapore.

Emuze, F. A. and Saurin, T. A. (eds). (2016). *Value and waste in lean construction*. Oxford: Routledge (Taylor and Francis). Available at: https://www.routledge.com/products/9781138903708

Fernandez-Solis, J. L., Porwal, V., Lavy, S., Shafaat, A., Rybkowski, Z. K., Son, K. and Lagoo, N. (2013). Survey of motivations, benefits, and implementation challenges of Last Planner System users. *Journal of Construction Engineering and Management*, 139(4), 354–360. Available at: http://www.ascelibrary.org

Gleeson, F. and Townend, J. (2007). *Lean construction in the corporate world of the U.K. construction industry*. Manchester, UK: School of Mechanical, Aerospace, Civil and Construction Engineering, University of Manchester.

Green, S. D. (1999). The dark side of lean construction: Exploitation and ideology. *Proceedings of the 7th Annual Conference of the International Group for Lean Construction*. 26–28 July. University of California, Berkeley, CA. pp. 21–23. Available at: http://www.ce.berkeley.edu/~tommelein/IGLC-7/PDF/Green.pdf

ILO ***see*** International Labour Organization.

International Labour Organization (2003). *National Report for Promoting the Linkages between Women's Employment and the Reduction of Child Labour*. Dar es Salaam: GENPROM.

Koskela, L. (1992). *Application of the new production philosophy to construction. Technical Report No. 72*. Stanford, CA: Center for Integrated Facility Engineering, Department of Civil Engineering, Stanford University.

Kumar, R. (2011). *Research methodology: A step-by-step guide for beginners*. 3rd ed. Los Angeles: SAGE.

Kusiak, A. (ed.). (1993). *Concurrent engineering: Automation, tools, and techniques*. New York: Wiley.

Marhani, M. A., Jaapar, A., Bari, N. A. A. and Zawawi, M. (2013). Sustainability through lean construction approach: A literature review. *AMER International Conference on Quality of Life*. 6–8 April. Holiday Villa Beach Resort & Spa, Langkawi, Malaysia. Available at: http://www.sciencedirect.com/science/article

Matias, J. and Cachadinha, N. (2010). Evaluating the potential benefits and challenges of LC adoption in the Portuguese construction industry: A survey study. *Proceedings of the 18th Annual Conference of the International Group for Lean Construction*. 14–16 July. Haifa, Israel. pp. 285–295.

Mossman, Alan (2009) "There really is another way, if only he could stop … for a moment and think of it"—Why isn't the UK construction industry going lean with gusto?. Lean Construction Journal 2009 pp. 24 - 36

Olamilokun, O. (2015). Investigating facilitators and barriers for adopting lean construction principles in the Nigerian building consulting firms. *International Journal of Innovative Research & Development*, 4(12), 234–239. Available at: www.ijird.com/index.php/ijird

Oyediran, O. S. and Akintola, A. A. (2011). A survey of the state of the art of e-tendering in Nigeria. *Journal of Information Technology in Construction*, 16(7), 557–576. Available at: http://www.itcon.org/2011/32

Rwelamila, P. D. (2009). Built environment research in SADC in a suffocating status? The dilemma of implementing research findings. *Proceedings of the 4th Built Environment Conference*. 17–19 May. Livingstone, Zambia. Cape Town: Association of Schools of Construction of Southern Africa (ASOCSA), Cape Peninsula University of Technology. pp. 90–104.

Sacks, R. M., Treckmann, M. and Rozenfeld, O. (2009). Visualization of work flow to support lean construction. *Journal of Construction Engineering and Management*, 135(12), 1307–1315. doi: 10.1061/_ASCE_CO.1943-7862.0000102

Salem, O., Solomon, J., Genaidy, A. and Luegring, M. (2005). Site implementation and assessment of lean construction techniques. *Lean Construction Journal*, 2(2): 1–21.

Sarhan, S. and Fox, A. (2013). Barriers to implementing lean construction in the UK construction industry. *The Built & Human Environment Review*, 6, 1–17. Available at: https://www.researchgate.net/publication/263658667

Seymour, D., Rooke, J. and Crook, D. (1998). Doing lean construction and talking about lean construction. *Proceedings of the 5th Annual Conference of the International Group for Lean Construction*. Gold Coast, Australia.

Shang, G. and Pheng, L. S. (2014). Barriers to lean implementation in the construction industry in China. *Journal of Technology Management in China*, 9(2), 155–173. doi 10.1108/JTMC-12-2013-0043

Sniegowski, B. and Royer, C. (2012). *AMER International Conference on Quality of Life*. 6–8 April. Holiday Villa Beach Resort & Spa, Langkawi, Malaysia.

UNESCO (2010). *Construction: A vibrant industry*. National Commission of the United Republic of Tanzania. Available at: http://www.natcomreport.com/Tanzania/pdf-new/construction.pdf

United Republic of Tanzania (2010). *Performance audit report on road works: The Ministry of Infrastructure Development and TANROADS' performance in controlling road construction time, cost and quality: A report of the controller and auditor general of the United Republic of Tanzania*. Available at: http://www.nao.go.tz/?wpfb_dl=83

United Republic of Tanzania (2012). *The Economic Survey 2011*. Dar es Salaam: President's Office, Planning Commission.

United Republic of Tanzania (2013). Tanzania Mainland Formal Sector Employment and Earnings Survey 2012: Analytical Report. Dar es Salaam: National Bureau of Statistics, Ministry of Finance.

United Republic of Tanzania (2015). *Government Budget for Financial Year 2015/16 – Citizens' Budget Edition*. Dar es Salaam: Ministry of Finance. Available at: http://www.mof.go.tz/mofdocs/budget

URT ***see*** United Republic of Tanzania.

Wandahl, S. (2014). Lean construction with or without lean – Challenges of implementing lean construction. *Proceedings of the 22nd Annual Conference of the International Group for Lean Construction*. June. Oslo, Norway. pp. 97–108.

Wandahl, S. and Bejder, E. (2003). Value-based management in the supply chain of construction projects. In C. M. C. T. Formoso (ed.). *Proceedings of the 11th Annual Conference on Lean Construction*. Available at: http://www.leanconstruction.dk/media/17592/Value-Based

Womack, J. P. and Jones, D. T. (1996). *Lean thinking: Banish waste and create wealth in your corporation*. New York: Simon & Schuster.

Wu, P. & Wang, X. (2016). A critical review of the factors affecting the success of using lean to achieve green benefits. *Proceedings of the 24th Annual Conference of the International Group for Lean Construction*. 20–22 July. Boston, MA. pp. 33–42.

Yang, G. F. (2014). Lean production system design and implementation in product life cycle. *Advanced Materials Research*, 1044–1045, 1768–1771. Available at: https://www.scientific.net/AMR.1044-1045.1768

AN INVESTIGATION INTO THE USAGE OF LEAN CONSTRUCTION TECHNIQUES IN NIGERIA

Olatunji J OLADIRAN[1]

[1]Department of Building, University of Lagos, Akoka, Yaba, Lagos, Nigeria, Email: ooladiran@unilag.edu.ng

ABSTRACT

Inadequate implementation of lean construction techniques poses a serious problem to the Nigerian construction process. The usage of lean techniques at the early stage of construction projects results in enhanced environmental performance, waste reduction, an increase in profits, and sustainable construction, among other things. This study focuses on the implementation of lean techniques, with a view to enhancing their usage, thereby improving the performance of construction projects. It examines the lean construction techniques that are used, as well as the extent of their usage, the implementation processes that are used, the benefits of improving usage of lean construction techniques in the study area, and the measures used to improve implementation of such techniques. In achieving these objectives, construction professionals from 10 organisations in Lagos State, Nigeria, were interviewed on 12 selected lean techniques. The data were analysed using descriptive statistics tools, namely means, frequencies, percentages, and modes. The findings reveal that fail-safe quality and safety, daily huddle meetings, increased visualisation, and the 5S process are poorly used, while the other eight techniques, namely Last Planner® System (LPS®), first-run studies, just-in-time (JIT), total production maintenance, concurrent design, kaizen, design for buildability, and supply chain management, are not used at all. Nevertheless, application of the aforementioned first four techniques has contributed to improved workflow on sites, maintenance of good site organisation, and increased job satisfaction among employees. It is recommended that top management, professional bodies, and institutions of higher learning make it a priority to offer education and training programmes on the concept of lean for workers on construction projects. Government should promote the concept of lean techniques, so as to encourage a culture of safety and improve productivity and performance on construction projects.

Keywords: lean, Nigeria, projects, techniques, usage

INTRODUCTION

There is emerging awareness of the concept of lean construction in the Nigerian construction industry compared to how it was about a decade ago (Adamu and Hamid, 2012). Olamilokun (2014) suggests that there is increasing readiness on the part of consulting firms in Nigeria to adopt lean techniques. This is also true of contracting organisations, and it could be due to growing awareness of such techniques. This is probably the industry's response to the objectives of projects and clients, as well as the imperatives of satisfying users, reducing waste, maximising value, and ensuring sustainability, among other things. However, there seems to be no direct proportionality between the industry's awareness of the multidimensional techniques of lean construction and its usage of such techniques, for

various reasons. One of the reasons that has been suggested is that the benefits of lean construction are visibly absent in most projects, and are generally limited to multinational medium and large construction organisations. The benefits of lean construction include increased focus on customer value, shorter project completion time, fewer faults and omissions, and greater customer satisfaction (Bertelsen, 2001). In this regard, Oladiran (2008) highlights the factors that could be germane to the non-extensive usage of lean construction in Nigeria. The factors highlighted are related to skills and knowledge, management, government, attitude, resources, and logistics, among other things. This study therefore investigates the extent of usage of 12 lean construction techniques in selected projects in Nigeria. The objectives are to examine the extent of usage of the techniques, the implementation processes used, the benefits of improving the usage of such techniques, and the measures used to improve implementation of such techniques. The significance of this study is in revealing the state of usage of lean techniques, which should hopefully stimulate efforts to improve the implementation and the benefits of such techniques.

LITERATURE REVIEW

There are several lean construction techniques that can be used to manage construction production effectively and efficiently. These include the Last Planner® System (LPS®), increased visualisation, the 5S process, just-in-time, and lean supply chain management (LSCM). The Last Planner® involves the supervisor or the foreman that is responsible for the site work, who plans and executes the work with the site team (Ballard et al., 2002). LPS® initiates communication among the workers, ensuring that the team understands and complies with the requirements of the Master Schedule, that it is involved in joint preparation of the Phase Pull Plan, and that it employs this Pull Plan to reveal the obstacles in carrying out their task (Engineers Australia, 2012). LPS® consists of three components, namely lookahead planning, work planning, and learning (Ballard et al., 2002). Lookahead planning is about arranging workflow sequence and rate, matching workflow and capacity, establishing a backlog of ready work (a workable backlog), and developing full plans on how to carry out the work. Work planning is the Last Planner®'s methodology for defining criteria to achieve good work. The criteria could comprise definitions, soundness, sequence, size, and learning. Previous plans are reviewed and analysed in the learning, so as to establish the causes for not meeting targets, and the relevant actions that need to be taken to prevent recurrence of the problem.

Increased visualisation fosters delivery of the most important information effectively to the workforce, via posting of various signs, such as schedules, safety signs, and quality signs. It reminds workers of elements such as workflow, performance, and specific actions (Moser and Dos Santos, 2003). Visual workplaces are built on the 5S process, which is a method for achieving a self-sustaining culture that results in neat, clean, and efficient workplaces. It eliminates excess materials and tools, and provides and maintains required resources. It makes available what one needs to do one's task, without more or less. It comprises five processes, namely "sort", "set in order", "shine", "standardise", and "sustain". "Sort" means getting rid of all materials or things from the workplace that are not needed for the current job. "Set in order" means arrangement of needed items in such a way that they are neatly arranged and easily identifiable. "Shine" means cleaning off all dirt from the workplace. "Standardise" means doing the right things always, including "sorting", "setting in order", and "shining". "Sustain" means engraving the 5S process in the mentality of all team members. 5S is applied in lean construction for materials storage and site areas of work (O'Connor and Swain, 2013). Just-in-time (JIT) focuses on reduction or elimination of inventories, resulting in minimisation of waste, through continuous improvement of

operations, equipment, and processes (Koskela, 1992). It takes into consideration other inventory less techniques, such as lot size reduction, layout reconfiguration, supplier cooperation, and set-up time reduction. Salem et al. (2005) assert that JIT views inventories as waste, and that materials and components should be made available only when required. Abdullah (2003) posits that JIT consists of three elements, namely JIT production, JIT distribution, and JIT purchasing. JIT production is having the exact amount of raw materials, work in process, or products required for production. JIT distribution is providing prompt delivery to customers or distributors. It prevents overproduction from occurring, because units are produced based on customers' requests and needs (Howell and Ballard, 1998). JIT purchasing is procuring or delivering the exact quantity of materials to the site as and when needed. JIT purchasing is practised on construction sites. JIT advocates continuous improvement, and it can help in value enhancement (Ajiboye et al., 2012). It is synonymous with lean material management functions (Engineers Australia, 2012). Lean supply chain management (LSCM) is a new network of suppliers enacted through cooperative relationships, while balancing cooperation and competition (Nightingale, 2005).

Implementation of LPS® in an industrial project in Egypt reduced the effect of risk factors on the time objective of the project (Issa, 2013). It significantly reduced the Percent Expected Time-overrun values and improved the Percent Plan Complete values on the project. Nine of the 13 risk factors were also minimised on the project by implementing lean techniques, as measured by a fuzzy model for time-overrun quantification. The nine factors were contractor problems and inadequate experience, unskilled workers and poor labour productivity, inefficient use of equipment, delays in material procurement, client's problems, inadequate and slow decision-making mechanisms, poor coordination among parties, rework, and improper accommodations for workers. It was recommended that lean construction techniques be adopted in developing countries, due to the simplicity and efficiency of such techniques. Swefie (2013) also revealed that standardisation, continuous improvement, housekeeping, customer focus, and reduced variability were efficiently used in the Egyptian projects investigated.

Similarly, Adamu and Hamid (2012) investigated the implementation of Last Planner System, increased visualisation, and huddle meetings in 80 housing units in Yobe State, Nigeria. 5S was not used, due to some constraints, such as unwillingness of the project participants. Leaders were assigned to each tool to monitor its application, implement the guidelines, and give feedback. It resulted in a reduction of the number of site operatives and the project duration when compared to similar projects that did not implement the selected techniques. It was observed that the project team did not welcome the idea of using the techniques, due to their perceived tediousness, but that team members' cooperation improved with the promise of financial incentives by the project manager. This indicates unwillingness among members of the construction industry to use lean techniques, as mentioned earlier, although awareness of such techniques is growing. It is interesting to note that in Adamu and Hamid's (2012) study, only three lean techniques were reluctantly used on the 80 housing units, and there were many constraints. The lean concept was linked to the objectives of the project, and the procedure was explained to the team before the reverse phase schedule meeting. All the team members participated in developing the reverse phase schedule activity programme. The weekly work plan was compiled for submission by the various trades before the weekly meeting, which addressed key issues on schedules, manpower, safety, construction, an early warning chart, and weekly work done, among other things. Safety signs, start and completion times of weekly work, and a Percent Plan Complete (PPC) chart were posted on the site, as part of implementation of increased visualisation. Weekly meetings were held for implementation of daily huddle meetings, but the meetings were more

frequent in the first, second and third weeks of the projects. All PPC values were above 70%, and information sharing on the project was enhanced.

Rajprasad et al. (2014) found that contractors in India were not familiar with the Last Planner System (LPS). Swefie (2013) found that visual management, just-in-time, collaboration, benchmarking, and prefabrication were not used in projects in Egypt. Rajprasad et al. (2014) reported that residential contractors use the Master Schedule method instead of LPS for their projects. However, LPS improved the schedule performance and prevented mistakes in the construction projects in which it was used. Thus, Rajprasad et al. (2014) concluded that with effective training on LPS, builders can avert schedule delays and improve the standard of projects via implementation of LPS. Realising this, this study investigates implementation of selected lean techniques in some Nigerian projects.

RESEARCH METHOD

The population of the study was building projects in Lagos metropolis, while the respondents were construction professionals. The professionals included architects, builders, quantity surveyors, and engineers. The convenience sampling technique was used to select a sample of 10 professionals from five indigenous and five foreign companies. These organisations were selected because, even though there is no list of organisations that practise lean construction techniques on their projects, the number of organisations that do implement such techniques are very few (Adamu and Hamid, 2012), especially in the research area. Data were collected via structured interviews conducted in five projects from each of the organisations, totalling 50 projects in all. The data were analysed using frequencies, percentages, means, and modes. The interview questions consisted of two parts. Part A solicited general information on the respondent and the organisation, including the type and the age of the organisation, and the experience and qualifications of the respondent. Part B investigated the usage, implementation, benefits, and measures used to improve implementation of 12 lean construction techniques on 50 projects from the respondents' organisations. The techniques were fail-safe quality and safety, daily huddle meetings, increased visualisation, the 5S process, the Last Planner® System (LPS®), first-run studies, just-in-time (JIT), total production maintenance, concurrent design, kaizen, design for buildability, and supply chain management. These techniques were selected because they are considered essential for the Nigerian construction process. Furthermore, they are among the most used lean techniques, especially the LPS, in several countries, with many benefits.

Mean usage percentage is calculated as

$$M = (n/50) * 100$$

where n is total number of projects on which a strategy was used, and
M is mean usage percentage.

FINDINGS AND DISCUSSION

Profile of the organisations and the respondents

The profile of the organisations and the respondents is presented in Table 1. Seven of the organisations were contracting firms, while three were consulting firms. Two of the organisations had existed in the Nigerian construction industry for between 0 and 5 years, three for between 6 and 10 years, two for between 11 and 15 years, one for between 16 and 20 years, and one for more than 20 years.

The profile of the respondents in Table 1 shows that two of the respondents held Higher National Diplomas (HNDs), four held a BSc degree, and four held an MSc degree. In terms

of experience, four respondents had been practising for a period of 0 to 5 years, four had been practising for 6 to 10 years, and two had been practising for 11 to 15 years. In terms of participation in projects, two of the respondents had participated in the production of between 1 and 5 projects, while eight had participated in between 6 and 10 projects. This finding suggests that the respondents can supply the required information.

Table 1: Profile of the organisations and the respondents

Organisations	**Type**	**Frequency**
	Contracting firm	7
	Consulting firm	3
	Total	**10**
	Age	**Frequency**
	0–5 years	2
	6–10 years	3
	11–15 years	2
	16–20 years	1
	More than 20 years	1
	Total	**10**
Respondents	**Academic qualification**	**Frequency**
	HND	2
	BSc	4
	MSc	4
	Total	10
	Experience	**Frequency**
	0–5 years	4
	6–10 years	4
	11–15 years	2
	Total	10
	Number of executed projects	**Frequency**
	1–5	2
	6–10	8
	Total	10

Usage of lean techniques

Table 2 shows that the lean technique that is used most is fail-safe quality and safety, with a mean usage percentage of 8%, followed by increased visualisation, with a mean usage percentage of 6%, followed by daily huddle meetings and 5S, each with a mean usage percentage of 4%. The other eight techniques were not used at all on any of the 50 projects. These techniques were LPS, first-run studies, just-in-time (JIT), total production maintenance, concurrent design, kaizen, design for buildability, and supply chain management. This shows that usage of lean techniques is very poor. In fact, the average mean usage percentage of the 12 techniques is 1.83%. This finding reveals the actual state of usage of lean techniques in Nigeria, which should hopefully stimulate efforts to improve implementation of such techniques. This finding confirms the findings of Rajprasad et al.'s (2014) study conducted in India, namely that contractors on residential projects did not use LPS. It seems that the scenarios in developing countries are similar, because lean construction is yet to be adopted in most developing countries; it is still a new concept (Adamu and Abdulhamid, 2015). Olamilokun (2014) opines that although there is readiness to adopt lean techniques in Nigeria, the required resources in terms of management, people, and technology are not available. He maintains that availability of trained professionals and education and skills development are the most important drivers of lean construction

principles. Thus, more awareness, education, and training are required to improve usage of lean techniques (Oladiran, 2008; Olamilokun, 2014).

Table 2: Usage of lean construction techniques

Lean construction technique	N	% M	R
Fail-safe quality and safety	4	8	1
Increased visualisation	3	6	2
Daily huddle meetings	2	4	3
5S process (visual workplace)	2	4	3
Last Planner® System (LPS®)	0	0	5
First-run studies	0	0	5
Just-in-time	0	0	5
Total production maintenance	0	0	5
Concurrent design	0	0	5
Kaizen	0	0	5
Design for buildability	0	0	5
Supply chain management	0	0	5
		1.83	

Implementation of lean construction techniques

The following are the various strategies or processes that are adopted for implementation of lean construction techniques by the various organisations that participated in the research:

Contracting organisation 1 (F 1)

- Daily huddle meeting: This is a daily start-up meeting, where team members quickly give a report of the previous day's activities. An expatriate from the United Kingdom who handled one of the projects introduced the principle. After the principle proved to be successful, it was accepted for implementation.

The daily huddle meeting was mandatory, and it was held between the project manager and the foremen. It started at 8 a.m. The longest meeting that was held lasted 30 minutes. The duration of the meeting depended on what was discussed in the meeting. The work of the previous day was reviewed, after each foreman gave a report, which included the number of workers in each section, the jobs done, the materials, tools, and equipment used, and the challenges faced by each trade section in terms of standardisation and safety and health of the workers. The daily huddle meetings improved the level of communication between the project manager and the foremen, resulting in a high level of commitment from workers on-site.

- Fail-safe quality and safety: This method relies on generation of ideas, which prevents potential defects in projects in terms of quality. All materials brought to the site were approved by the Standards Organisation of Nigeria (SON), and most of the time the materials were tested in designated workshops and laboratories, to ensure good quality. In terms of safety, a safety officer certified with the Nigerian Institute of Safety Professionals (NISP) ensured that all workers were properly kitted out before commencement of the day's work, such as wearing of safety boots and helmets at all times during site work. Any workers that were not properly kitted out were dismissed from that day's work without pay. A toolbox and warning signs were also routine features on-site. Efforts by the team to check for quality and safety on-site were problematic because of social problems, and much effort was required to ensure that all foremen were well informed of their job description and the need for compliance with safety procedures.

The level and process of communication on-site concerning fail-safe quality and safety was significant, such that if any worker noticed that anyone was not safety-compliant, or noticed any defect in materials brought to site, he would notify the project manager.

Consulting organisation 1 (F 2)

- Increased visualisation: This was used to deliver key information effectively to the workforce, through the process of posting signs on the site, especially safety signs. Safety signs were posted all over the site by a certified safety officer. Mobile signs were also posted so as to enable workers and guests know how to move on the site. A chart of project milestones, which is essential, was also available in the project manager's office. It was extracted from the project planning chart using a Gantt chart.
- 5S process/visual workplace: This was used to increase transparency and eliminate wasteful resources on the site. Foremen were given complete responsibility for selecting the tools needed for an operation, and for submitting the list of tools to the site engineer for cross-checking and approval. The list would be given to the storekeeper, who would make it available to the workers when it was needed. After tools had been issued to the workers, a list was prepared to ease the way the tools would be returned. The tools would be placed neatly in the presence of the storekeeper. The material layout design was also prepared, which contained key details of the work activities of each day, together with the tools that would be needed. Foremen were given the task of ensuring that each worker tidied up where they had worked, and also that they informed the site clerk that they could inspect where they had worked.

Contracting organisation 2 (F 3)

- 5S process/visual workplace: The site clerk was charged with selecting and placing separately the materials/tools needed for each day's operations, with the help of each trade foreman. He also ensured that materials and tools were placed in a regular pattern where they were to be used, for ease of access during operations. The site clerk collected the material layout design, and the foreman set about familiarising himself with each work activity on-site, in order to provide the needed tools. After the day's work, the site clerk ensured that the work area was cleaned, and that all tools were also cleaned, lubricated, and arranged neatly in the store.
- Fail-safe quality and safety: The slogan "Safety first" was posted in designated areas, which made all workers on-site safety-conscious and compliant with safety rules and regulations. All materials brought and used on-site had to meet SON standards.

Contracting organisation 3 (F 4)

- Fail-safe quality and safety: Materials brought to the site were certified by the SON, and proof of the certification was seen by the site manager. Material testing was done, namely concrete and reinforcement testing. All foremen were in charge of the safety of their workers, and they distributed safety gadgets to their workers. Workers were mandated to wear the safety gadgets that were given to them.
- Daily huddle meetings: Meetings were held with the workers on-site on a weekly basis, especially on Mondays. The discussions in the meetings were about overlapping activities and identifying potential problems on the jobsite. Site management personnel met on a daily basis for at least 10–15 minutes to review work. This helped to enhance communication between project personnel and the foremen. The level of late-coming to site was reduced, and the level of commitment of workers increased.

Contracting organisation 4 (F 5)
None of the techniques were known or used.

Consulting organisation 2 (F 6)
Daily huddle meetings: The huddle meetings were not as consistent as those of previous years. As at the time of this survey, the meetings were held every month on a Saturday, with the full involvement of all employees on the projects. Issues were tabled during meetings to find quick solutions. The meetings usually involved the site foremen. The project manager held meetings with the engineers on-site, including the site foremen, and he later gave feedback to the management.

Contracting organisation 5 (F 7)
Fail-safe quality and safety: The qualities of materials brought to the site by long-standing suppliers were of a good standard. Workers were given training on safety on-site, so as to increase the level of safety on-site. Certified safety officers ensured that workers on-site complied with safety rules, and they also made sure all workers were properly kitted out before commencement of the day's work. Any worker that was not safety-certified was not employed.

Consulting organisation 3 (F 8)
None of the techniques were known or used.

Contracting organisation 6 (F 9)
Increased visualisation: Signs were posted on the site to communicate key information that must be adhered to. The signs posted were those related to safety, the schedule, and quality. The schedule stipulated the work to be done for each day, within a specific period.

Contracting organisation 7 (F 10)
None of the techniques were known or used.

The above findings have established the extent to which lean techniques are implemented on Nigerian projects. The findings could serve as a benchmark for implementation of lean techniques in any project undertaken elsewhere. It is noteworthy that the pattern of implementation, particularly for increased visualisation and daily huddle meetings, is similar to that observed in Adamu and Hamid's (2012) study conducted in Yobe State, Nigeria. The similarity of the findings in the two studies confirms the actual state of implementation of lean techniques in Nigeria.

Benefits of lean construction techniques
The various benefits of lean techniques on the investigated projects are shown in Table 3. A major benefit is waste reduction, both in materials, labour, and time. One of the key problems noticed on Nigerian construction sites is material waste. This study has confirmed that lean construction is a solution to this problem if it can be fully embraced and integrated into the Nigerian construction industry. This study gives credence to Ogunbiyi et al.'s (2012) assertion that usage of lean practices and techniques results in improvement in environmental performance, a reduction in waste, an increase in profits, and improvement of workflow. All the benefits mentioned by Ogunbiyi et al. (2012) were experienced in the projects investigated. Other benefits experienced in this study were enhanced communication and worker participation, maximisation of value, safety, and worker satisfaction, among other things.

Table 3: Benefits of lean techniques

Technique	Organisation	Benefits
Daily huddle meetings	F 1	They helped significantly to reduce waste in terms of the workforce in some operations. They created a sense of belonging among the workers. They promoted free flow of information on-site, which fostered good relations among the workers.
	F 4	They improved communication between the project personnel and the foremen. The level of commitment of the foremen on-site was high, which reduced the level of late-coming to site.
	F 6	They increased employees' job satisfaction, and workers' problem-solving ability was enhanced. They added value and promoted discipline.
Fail-safe quality and safety	F 1	It led to a reduction in site accidents. It improved quality.
	F 3	It helped to ensure safety. Certified professionals trained workers on-site, which improved work performance on-site.
	F 4	Communication was enhanced, because the foremen took charge of their workers' welfare. It helped to maintain a standard safety culture.
	F 7	It drastically improved the workers' safety (the number of injuries on-site were reduced) and customer satisfaction, it increased value, and it lowered costs.
Increased visualisation	F 2	It gave team members a sense of belonging on-site, and it reduced waste. It eliminated idleness on-site, and it helped team members to know the scheduled duration of a project.
	F 9	The performance of workers improved, as well as their level of commitment. It improved the workflow on-site, and the level of wastage was reduced.
5S process (visual workplace)	F 2	It helped to maintain a high level of site organisation, and it helped to reduce waste on-site. The level of housekeeping was high.

	F 3	It improved the rate of workflow on-site, and it facilitated maximum coordination in the handling of tools.

Measures for improving implementation of lean construction techniques

The following are suggestions by the interviewees for improving usage of lean construction techniques in Nigeria:

- Training: Construction project stakeholders require ample training for knowledge and skills acquisition on the concept of lean. Training shouldn't be restricted to skilled workers only, but should be available to foremen on sites, in order to improve productivity and performance.
- Top management support: Adequate support from decision makers, or policy formulation in organisations, is necessary for the concept of lean to thrive in construction projects.
- Government intervention: The Nigerian government needs to promulgate laws or codes of practice that will enhance usage of novel techniques, such as lean and others.
- Good communication and collaboration: There is a need to improve communication between all parties in projects. There should be active communication among clients, consultants, and contractors. Regular meetings between parties are required to educate workers on the concept of lean, as well as lean principles.
- Deep understanding: The level of understanding of the concept of lean is directly proportional to its usage and benefits.
- Commitment: successful implementation of this concept will require commitment and cooperation from workers.

The above suggestions are compelling reason for implementing lean construction techniques in Nigerian construction companies. However, Olamilokun (2014) is of the opinion that Nigerian companies are not ready for adoption of lean. His study, however, recommends continuous awareness and training for Nigeria, which is consistent with the findings of this study. Oladiran (2008) also recommends education and skills development, management and four other groups of strategies in order to adopt lean in Nigeria, which is consistent with the findings of this study. It can be concluded that concerted execution of the findings of this study and those of Oladiran (2008) will assist greatly in implementing lean in Nigeria.

CONCLUSIONS

The study was premised on the finding that lean construction techniques are not adequately used in Nigerian construction projects. Based on this premise, the study investigated 12 selected lean techniques on construction projects. The study concluded that lean techniques are poorly used in Nigeria. Implementation of the techniques that were used on the sites involved various processes and steps to realise the benefits associated with lean techniques. Some of the benefits of implementing lean construction techniques include waste reduction, enhanced communication and worker participation, maximisation of value, safety, and worker satisfaction. Measures that can be applied to improve the low level of usage of lean techniques include training, top management support, government intervention, good communication and collaboration, deep understanding, and commitment.

RECOMMENDATIONS

The following recommendations are made based on the findings of this study:

- Construction organisations should increase their usage of lean construction techniques, so as to attain better project performance. This can be done through deliberate decisions by the management, and formulation of policies that favour new construction technology, such as lean. Outcomes of increased usage of lean techniques could include a good construction workflow, a reduction in water consumption, and increased profits, among other things.
- Construction professionals that are tasked with implementation of construction techniques on projects should expose themselves to the state-of-the-art process of implementing lean techniques. This can be done by learning from expatriates that have used lean in foreign projects, reading relevant research articles and books, and participating in seminars, workshops, and conferences.
- Government should promulgate laws, regulations, and codes of practice that will embrace the use of lean construction techniques. They could be part of the items or sections in government documents regulating the construction industry.
- The measures for improving implementation of lean construction techniques should be applied by all stakeholders. This could start by creating more awareness and conducting training on lean for various stakeholders. Specific lean techniques could also be stipulated and mandated by clients, project team leaders, project coordinators, and construction agencies.

ACKNOWLEDGEMENT

This article was language-edited by a freelance language editor, Anthony Sparg. He has edited several academic journal articles and master's theses in the field of construction management. He has an MA *cum laude* in African Languages (isiXhosa), an MA *cum laude* in Linguistics, and a Higher Diploma in Education.

REFERENCES

Abdullah, F. (2003). *Lean manufacturing tools and techniques in the process industry with a focus on steel*. PhD thesis. Graduate Faculty of School of Engineering, University of Pittsburgh, Pittsburgh, PA.

Adamu, S. and Abdulhamid, R. (2015). Suitability of lean construction approach in Nigerian project delivery. *Journal of Multidisciplinary Engineering Science and Technology*, 2(10), 2676–2679.

Adamu, S. and Hamid, R. (2012). Lean construction techniques implementation in Nigeria construction industry. *Canadian Journal of Environmental, Construction and Civil Engineering*, 3(4), 186–193.

Ajiboye, T. K., Alabi, A. G. F. and Adedokun, G. (2012). Application of lean manufacturing method in small and medium scale industries in Nigeria. *Journal of Engineering and Applied Sciences*, **7**(2), 232–237.

Ballard, G., Tommelein, I., Koskela, L. and Howell, G. (2002). Lean construction tools and techniques. In: R. Best and G. de Valence (eds.). *Design and construction: Building in value*. Oxford, UK: Butterworth-Heinemann, Elsevier.

Bertelsen, S. (2001). Lean construction as an integrated production. *Proceedings of the 9th Annual Conference of the International Group for Lean Construction*, 6–8 August. Singapore. pp. 25–46.

Engineers Australia (2012). *Recommended practices for the application of LEAN construction methods to building new Australian LNG capacity*. Barton, Australia: Engineers Australia. doi: 987-0-85825-975-1

Howell, G. and Ballard, G. (1998). Implementing lean construction: Understanding and action. *Proceedings of the 6th Annual Conference of the International Group for Lean Construction*. 8–20 January. Guaruja, Brazil.

Issa, U. H. (2013). Implementation of lean construction techniques for minimizing the risks effect on project construction time. *Alexandria Engineering Journal*, 52(4), 697–704.

Koskela, L. (1992). *Application of the new production philosophy to construction. Technical Report 72*. Stanford, CA: Center for Integrated Facility Engineering, Stanford University.

Moser, L. and Dos Santos, A. (2003). Exploring the role of visual controls on mobile cell manufacturing: A case study on drywall technology. *Proceedings of the 11th Annual Conference of the International Group for Lean Construction*. 22–24 July. Virginia Tech, Blacksburg, VA.

Nightingale, D. (2005). *Lean supply chain management and principles: Integrating the lean enterprise*. Cambridge, MA: Massachusetts Institute of Technology.

O'Connor, R. and Swain, B. (2013). *Implementing lean in construction: Lean tools and techniques – an introduction*. London: CIRIA.

Ogunbiyi, O., Oladapo, A. A. and Goulding J. S. (2012). Lean procurement: The use of lean construction techniques in project value enhancement. *Proceedings of the Joint CIB W070, W092 & TG72 International Conference on Facilities Management, Procurement Systems*. 23–25 January. University of Cape Town, Cape Town.

Oladiran, O. J. (2008). Lean-in-Nigerian construction: State, barriers, strategies and "Go-To-Gemba" approach. *Proceedings of the 16th Annual Conference of the International Group for Lean Construction*. Manchester, UK.

Olamilokun, O. (2014). *An appraisal of the readiness of Nigerian building consulting firms to adopt lean construction principles*. MSc thesis. Department of Quantity Surveying, Faculty of Environmental Design, Ahmadu Bello University, Zaria, Nigeria.

Rajprasad, J., Saminu, S. and Babu, S. H. (2014). A study and application of lean construction techniques using Last Planner concept in residential building. *International Journal of Engineering Development and Research*, 2(3), 3264–3270.

Salem, O., Solomon, J., Genaidy, A. and Luegring, M. (2005). Site implementation and assessment of lean construction techniques. *Lean Construction Journal*, 2(2), 1–58.

Swefie, M. G. (2013). *Improving project performance using lean construction in Egypt: A proposed framework*. MSc thesis. Department of Construction and Architectural Engineering, The American University in Cairo, Egypt.

TRACES OF LEAN CONSTRUCTION PRACTICES IN THE INDIGENOUS BUILDING CULTURE OF THE TALENSI OF NORTHERN GHANA

Zoya Evans KPAMMA[1], Eric Kwaku ASARE[2] and Emmanuel Nsiah ANKOMAH[3]

[1]Department of Building Technology, Sunyani Technical University, Sunyani, Ghana, +233 244787599, Email: evanskpamma @ yahoo.co.uk
[2]Department of Building Technology, Sunyani Technical University, Sunyani, Ghana, +233 209191730, Email: asare_kwaku_eric@stu.edu.gh
[3]Department of Building Technology, Sunyani Technical University, Sunyani, Ghana, +233 244590709, Email: bd310nsiah@gmail.com

ABSTRACT

Lean construction (LC) is a project delivery system that focuses on delivering projects to meet the needs of clients while minimising waste. Even though a number of authors have indicated a strong link of LC to the Toyota Production System, there appear to be traces of LC in some indigenous building cultures. A closer study of the indigenous construction practices of the Talensi of Northern Ghana reveals traces of an LC philosophy. An attempt to establish an apparent link between the indigenous building culture of the Talensi and the concept of LC was carried out through field observations, interviews and a literature review. The study points to the fact that even though the term 'lean construction' might not have been coined by then, traces of LC as a culture, such as ensuring reliable flow, promoting collaboration, ensuring respect for people and improving transparency, were identifiable with the indigenous building culture of the Talensi. The outcome of this study should provide a basis to enhance the geographic spread of LC implementation by regenerating indigenous practices that identify with the lean concept.

Keywords: Talensi, lean construction, collaboration, transparency, indigenous building culture

INTRODUCTION

A number of authors trace the foundation of the lean concept to the Toyota Production System (TPS) which is founded on the philosophies of continuous improvement and respect for people (Ohno, 1988; Womack and Jones, 2003; Liker,

2004). The term 'lean construction (LC)' was coined to contextualise lean principles within the architecture, engineering and construction (AEC) sector towards optimising value and reducing waste in the sector (Forbes and Ahmed 2011; Rybkowski et al., 2013). LC encourages a radical shift from the conventional approaches in construction to improved processes in order to meet customer needs and concerns.

Even though an understanding of the LC concept and its implementation strategies appears diffuse among practitioners and theorists, some common themes run through the various perceptions of LC and approaches at operationalising it. These themes, among others, include value generation, waste reduction, continuous flow, constant improvement, collaboration, concurrent engineering, participation, transparency, trust, and respect for people. Fulfilling and adhering to these themes in the practice of LC have led to the devising and adopting of various tools and systems such as the Last Planner System (LPS), Integrated Project Delivery (IPD), Lean Project Delivery System (LPDS), Target Value Design (TVD), Set-Based Design (SBD), Choosing by Advantages (CBA), standardisation, and Building Information Modelling (BIM).

Most of the documented practices of LC, especially those to be found in International Group for Lean Construction (IGLC) literature, have largely focused on separate or combined implementation of the LC tools and systems within contemporary construction settings. This article, however, brings to the fore some elements of LC associated with construction practices in antiquity. The paper specifically traces elements of LC practices within the traditional building culture of the Talensis of Northern Ghana. The Talensis are traditionally the native inhabitants of the current Talensi district in the Upper East Region of Ghana. Although the level of diffusion of LC is generally seen to be low, particularly in African countries such as Ghana (Kpamma and Adjei-Kumi, 2011), and a myriad of obstacles has been identified as possible challenges against the implementation of LC in Ghana (Ayarkwa et al., 2012), this research sought to identify some indigenous building construction practices which could be regenerated to provide a foundation for the geographic diffusion of LC, especially in Ghana as well as Africa as a whole.

LITERATURE REVIEW

Lean construction practice

One strategy of applying lean principles in construction requires the distinguishing characteristics of construction (compared to manufacturing), such as the one-of-a-kind nature of projects and temporary multi-organisation, to be minimised or given less recognition. This is in agreement with those who advocate that successfully implementing lean principles in construction requires construction to be more like manufacturing (where lean thinking originated). Koskela (1992), suggesting an approach to dampening the "one-of-a-kind" feature of construction process, indicates that exclusive solutions in a project not critical to the value of the project, but arising from

client or site idiosyncrasies, or the artistic expression of the designer, could be disregarded. In this way, he explains, proven standard work flows and associated components and skills could be employed. Koskela (1992) further recommends such actions as standardising components and processes, employing modularisation and prefabrication, as well as using enduring teams as practices to reduce the uniqueness of construction and bring it closer to manufacturing.

Ballard and Howell (1998), however, argue that, in line with the consideration of bringing construction closer to manufacturing, continuous waves of implementation would always result in remnants that have not yet been reduced to manufacturing and therefore are not yet capable of being made lean. Although the approach of making construction like manufacturing provides remarkable potential to reduce the time and cost of constructed facilities, the real challenge, Ballard and Howell assert, is to recognise the peculiar features of the remainder and to make them lean. A double-tier strategy of implementing lean in construction is therefore proposed (Ballard and Howell, 1998): (i) claiming for construction what essentially belongs to modern product manufacturing and minimising construction's distinctiveness towards taking advantage of lean techniques in manufacturing; and (ii) developing lean techniques adequate to dynamic construction, the remainder that resists the first approach.

Initiatives such as manufactured housing seem to adopt the first strategy of minimising construction's peculiarity. Simplifying site construction to final assembly and testing is one example of minimising construction's peculiarities. The second strategy of formulating lean techniques which are responsive to the uniqueness of construction poses the utmost challenge in implementing lean since it proposes to make lean a type of production that is not manufacturing (Ballard and Howell, 1998).

It has further been observed that when applying lean in construction, product and process design can be standardised for standard products. However, for non-standard products, it is necessary to standardise at the meta-level of planning and control so that standard procedures for planning and managing the design and installation of unique facilities are developed. This requires the creation of social unity among project participants as a prerequisite for collaborative process mapping and streamlining to order to maximise customer value and minimise waste (Ballard and Howell, 1998). The need for social unity in lean implementation is corroborated by Koskela (2015) when, in attempting to align lean and rhetoric, he points to the creation of a common ground as an essential activity to both lean and rhetoric.

The creation of social unity requires activating LC soft skill requirements (e.g. respect for people, transparency and trust) to nurture collaboration. Howell (2013), for instance, points out that one measure of creating a balance to minimise the diversity among members within project teams towards process efficiency is to introduce non-economic incentives such as fairness, equity and trust. It has, however, been observed that a section of practitioners and researchers, unfortunately, focus on the hard elements of LC skills (e.g. engineering process of flow, kanban standardisation, work-in-progress,

just-in-time delivery) to the neglect of the soft elements such as the social aspect of lean thinking (Liker, 2004; Santorella, 2011; Rybkowski et al., 2013).

Another approach to implementing lean in construction is to exploit the synergy between lean and sustainability, especially in the area of waste reduction for environmental performance and productivity. Waste, from the perspective of lean, refers to resources or activities that are time consuming and incur cost without creating value (Koskela, 1992). Sustainability is the long-term preservation and improvement of the well-being of man in the midst of limited planetary resources (Golzarpoor and Gonzalez, 2013). Sustainability has environmental, economic and social dimensions (Wentworth, 2012). It is argued that it is possible to integrate environmental concerns into lean approaches to reduce waste, save cost, and mitigate impact on the environment (Bantowsky, 2007). This illustrates the environmental or "green" dimension to implementing lean in construction (Golzarpoor and Gonzalez, 2013).

Building culture of the Talensi

The inhabitants of the Talensi area in the Upper East region of Ghana in West Africa are culturally and administratively termed Talensis (or 'Tallensi', as spelt by some authors). The cultural heritage of the Talensis is characteristically expressed in both their performing and visual arts, such as traditional architecture. The indigenous building culture of the Talensis is primarily centred on the design and construction of the homestead. The homestead is traditionally identified as a Talensi man's focus and fount of his key interests, his foremost drives, his deepest emotional connections and his entire structure of values; it his shelter, his storehouse and the stage of his life's drama (Fortes, 1949).

Cardinall (1920) suggested that house-building among the Talensi was planned and constructed sothat natives could defend themselves against hostile neighbours. Fortes (1949), however, asserted that, rather than the alleged lawlessness of earlier times, the mode of house-building by the indigenous Talensi was determined by such considerations as material availability, economic system and social organisation. Subsequent findings by Prussin (1974) as well as Schreckenbach and Abankwa (1983) tend to corroborate the views of Fortes (1949).

Traditionally, house-building among the Talensi goes beyond a mere physical process to a social process. Guided by a strong sense of kinship, house-building by a Talensi man is seen as a co-operative effort by the clan to which he belongs. The house construction process mobilises the social ties of the man, and the constructed house stands as an embodiment of the efficacy of those social ties (Fortes, 1949). A bird's eye view of an indigenous Talensi homestead or neighbourhood depicts a material projection of the social relations that make up a family or clan.

RESEARCH METHOD

This article sought to trace elements of LC practices in the indigenous building culture of the Talensi in northern Ghana. The study largely relied on empirical knowledge of and literature on the indigenous building practices of the Talensi. At the time of conducting this study, the authenticity of the indigenous building practices of the Talensi had admittedly been generally compromised by the infiltration of contemporary cultural and construction practices, especially in the past two decades. The principal source of empirical data for the study, which was ethnographic in nature (Creswell, 1998), was based on the previous experiential knowledge of one of the authors who is a native, and grew up in the Talensi area. This author was not only an observer of the indigenous building practices, but also an active participant in the process (especially from 1980 to1995).

The experiential knowledge of the author was further verified by an interview with three traditional Talensi builders as well as by documented studies on the Talensis, especially those by Fortes (1945, 1949), Prussin (1974) as well as that of Schreckenbach and Abankwa (1983). Fortes is renowned as an anthropologist for his extensive ethnographic study of the people of Talensi and Ashanti in Ghana, culminating in notable works such as *The Web of Kinship among the Talensi* and *The Dynamics of Clanship among the Talensis*. Prussin (1974), as well as Schreckenbach and Abankwa (1983), produced notable seminal works on the traditional architectural and construction practices of inhabitants across various ethnic and climatic regions of Ghana and parts of Africa.

The analysis of data basically involved matching patterns of indigenous construction practices identifiable with the lean philosophy as they emerged from the multiple sources of data: the author's experiential knowledge, interviews and documentation. The specific themes that guided the pattern-matching process towards establishing a convergence between indigenous Talensi building practices and LC included collaboration, standardisation and sustainability. Literature reveals collaboration, standardisation and sustainability as fundamental elements in the implementation and practice of LC.

FINDINGS

This section presents and discusses identified practices in the Talensi indigenous building culture aligned to LC. The findings are presented along the LC themes of collaboration, standardisation and sustainability.

Collaboration

One of the key elements of LC is the stimulation of a collaborative atmosphere among project participants to enhance information sharing and a striving towards shared objectives. Collaboration as an element of lean has been expressed in various forms in LC literature. Ballard and Howell (1998) called for social unity among project

participants as a measure for collaborative planning and streamlining processes to maximise value and minimise waste. Koskela (2015) contends that, in many ways, LC attempts to create a common ground of values and facts among project participants.

Among the Talensis, collaboration is one of the strong manifestations of the social process in traditional house-building. Across the entire construction process, from site preparation to finishing, participants of diverse ages, social standing, skills and genders are involved. As Fortes (1949) observes, erecting the walls tier by tier, roofing the rooms, as well as finishing the walls and floors are tasks requiring considerable dexterity and cooperation among the participants. Collaboration within and across tasks fundamentally emanates from a strong kinship among the participants, based on the sharedness of their social ties with the owner of the project. Since most of the participants are generally connected by social ties, identify with the value of the project and share in its success, they are united in planning and working towards achieving the project goal. Figure 1 illustrates a case of collaboration in traditional wall construction and finishing process by participants who, through the strength of their kinship, share in the value and success of the project.

Figure 1: Collaborative wall construction and finishing process

Another dimension of collaboration in the building culture of the Talensi is the reliance on non-economic incentives to intrinsically motivate participants. Intrinsic motivation is significant in achieving collaboration towards lean project delivery (Darrington and Howell, 2010; Schöttle and Gehbauer, 2012). Although there is some form of reward in the form of foodstuffs for participants by the project owner (Fortes, 1949), this, rather than being an economic reward, is fundamentally meant to replenish the energy expended by participants in performing their various tasks. Participants' collaboration and performance in this case are intrinsically motivated by non-economic incentives such as trust, personal values and social norms. The ideals of trust and fairness are typical virtues shared among indigenous Talensis, based on which members of a clan, who essentially constitute the project team, voluntarily feel obliged to collaborate in building a house for a kinsman in anticipation of long-term reciprocal

assistance. The relationship among the project participants, including the owner, therefore follows a rational contractual arrangement which is argued (Lichtig, 2005) as able to build associations healthy enough to endure the inevitable conflicts and challenges that come with project delivery.

Respect among project participants was one of the identified drivers of collaboration in the traditional construction process of the Talensi people. Even though various individuals, through apprenticeship, specialise in specific tasks of the traditional construction process (e.g. earth kneading, moulding and masonry), the atmosphere of respect tends to relax the dichotomy among participants along the lines of professional expertise, thereby fostering integration among teams towards value delivery. There is mutual recognition among participants in respect of the crucial role of every participant along the project delivery chain.

The prevalence of shared mental models among project participants is also one of the elements of collaboration in the indigenous building culture of the Talensi. Similarity in mental models among project participants, Mathieu et al. (2000) observe, results in team members working towards common objectives with a shared cognition of how the team will function. One of the areas where the participants share mental models is knowledge of the capabilities and responsibilities of the various project participants. Essentially all members of the team do not only live and work together in one community, but may also have participated in previous projects, making it possible for familiarity in respect of member talents and capabilities. In alliance with this observation, Koskela (1992) recommends the use of enduring teams as a strategy to reduce the uniqueness and the one-of-a-kindness of construction projects in order to bring construction closer to manufacturing for lean implementation.

Standardisation

Standardisation of products and processes is one of the recommended strategies for implementing lean in construction by making construction more like manufacturing (Koskela, 1992; Ballard and Howell, 1998). Design and construction of indigenous houses of the Talensi are standardised in various dimensions. This contributes significantly to a reduction in uncertainty and process variability, thereby enhancing flow, efficiency and collaboration. The repetitiveness, predictably and recurrence of a standardised process, apart from resulting in cost reduction, also allow the project participants to understand what is required (from whom, and by when), therefore leading to an enhanced transparent process, fewer conflicts, fewer change orders, reduced unplanned schedules and costs, as well as a more stable workflow (Gibb and Isack 2001, Pasquire and Gibb 2002; Tam et al., 2007).

One manifestation of standardisation in the traditional architecture of the Talensi is the layout of the homestead which is standardised along the social connections and hierarchical relationships among the occupants. The family compounds and homesteads are standardised sociograms of the kinship groups (Prussin, 1974). Fortes (1949) observes that individual idiosyncrasies do not affect the layout of a homestead so that apart from minor variations, the layout wholly depends on the composition of the

domestic unit. This, incidentally, agrees with the view of Koskela (1992) who recommends a reduction of client idiosyncrasies towards standardisation in order to address the challenge of the "one-of-a-kind" nature of construction, when implementing lean in construction project delivery process.

Another element of standardisation in traditional Talensi architecture is the choice of building form. The circular form is generally the standard choice for indigenous buildings among the Talensi. In the north-eastern half of Ghana of which Talensi forms part, Schreckenbach and Abankwa (1983) identified buildings to be generally circular and arranged as cells around an inner courtyard. An aerial view shows every traditional Talensi homestead as covering a roughly circular area (Fortes, 1949). The standardised choice of a circular form is drawn from various considerations (Prussin, 1974). One consideration is the continuity of the circular form which is a source of structural stability for the earthen walls. Another consideration is that the circular form, unlike a rectangular form, helps to concentrate thermal radiation in a central enclosed interior space to balance the wide diurnal temperature range of the savannah to enhance interior comfort. It is also considered that the curvilinear surfaces, combined with the coarse texture of the earthen walls, eliminate the harsh and irritating contrast between light and dark created by perpendicular intersecting planes, and adapt it to softly graded shade and shadow (Prussin, 1974).

Standardisation of the traditional architecture of the Talensi is also shown in the choice of construction materials and process. Wall construction as a standard process, for instance, generally involves hand-moulding kneaded laterite into standard spherical sizes and using the balls to construct the wall tier by tier. Wall finishing also involves a standardised process of plastering the wall surfaces with a mixture of mud, cow dung and juice from boiled empty locust bean tree pods. The juice acts as a stabiliser, hardener and waterproofing.

Furthermore, standardisation reflects in the planning and scheduling of the construction process. In the view of Ballard and Howell (1998), where there is difficulty in standardising construction products for implementing lean, the recommended approach is to standardise at the meta-level of planning and control so that standard procedures for planning and managing the design and installation of unique facilities are developed. As a standard schedule, traditional Talensi construction generally occurs in the dry season between December and April. This period is without rainfall and the entire construction process, from site preparation to wall and floor finishing, is planned in this period. The need to standardise the construction schedule within this period is further reinforced by the fact that most traditional construction participants are farmers and would be engaged in farming in the rainy season. The standardised scheduling in the dry season is transparent and understood by all participants, thereby enhancing the reliability of the commitment of the entire team to planned activities for projects. This tends to stabilise the flow of construction activities within the planned durations.

Sustainability

Sustainability is critical to LC, especially in respect of waste reduction as well as social and environmental friendliness (Ogunbiyi et al., 2014). One element of sustainability of the indigenous building culture of the Talensi is the environmental friendliness of the process which is associated with less generation of waste. This fundamentally stems from the recyclability and reusability of the traditional materials, especially laterite for wall construction. Apart from the earth from borrowed pits (Prussin, 1974), another source of material for traditional wall construction among the Talensi is to remold broken walls from old buildings. This involves soaking and mixing the broken pieces in water before kneading them into workable consistency. The implication is that decommissioned walls can readily be reused or recycled into new walls without any trace of waste.

Another dimension of the environmental sustainability of the building culture of the Talensi is the ability of the traditional building materials to merge back into the natural environment when they are not in use. When the earth used for the wall and roof (in the case of flat mud roofs) construction is disposed of, it easily merges with the top soil to support farming activities, thereby leaving no evidence of waste. The biodegradable nature of materials for the thatch roofs also puts them in a position to easily merge with the natural environment when they are decommissioned.

The sustainability of traditional Talensi architecture also finds expression in the adaptability of the compound residence to changing family size and relationships. Prussin (1974) observed the uniqueness of the compound residence in respect of its kinetic quality in that it reflects the varying connections in the cycle of the family lifespan. As the joint family expands with the addition of more children and wives (Fortes, 1949), the compound expands adaptively through the addition of new, enclosed or clearly demarcated extensions in space (Prussin, 1974). The use of non-permanent materials particularly plays an important role in the adaptation of the traditional Talensi homestead to the changing family size and social connections. The earthen wall construction is easily demolished and remolded in the adaptation process. The loose-fit connections in the traditional thatch roofing system allow for easy demounting and reassembling of roofs.

DISCUSSION

The findings as presented above indicate a strong convergence of some fundamental elements of LC with indigenous construction practices of the Talensi. Specifically, collaboration, standardisation and sustainability are fundamental to both LC and indigenous Talensi construction. Collaboration, a critical element in a successful LC implementation, is largely driven by a good sense of community which intrinsically motivates indigenous Talensi inhabitants towards shared goals and respect for people in their traditional construction undertakings. Standardisation, which is also essential in aiming at a lean culture (Höök, 2008), generally manifests not only in the repetitiveness of the building form and materials of Talensi architecture, but also in the recurrence and predictability of the production process which is associated with a smooth and

standardised pace. Sustainability is expressed, not just in the friendliness and responsiveness of the traditional building materials to the physical environment, but also in the reduction of waste and the enhancement of value as result of the reusability, recyclability and adaptability of materials and form. Even though the LC practices of collaboration, standardisation and sustainability may not necessarily represent the total culture of LC practice, their pervasiveness in a particular setting presents a fertile foundation to extend to other LC practices.

Notwithstanding the prevalence of elements of LC in the indigenous building practices of the Talensis, some other components of these practices appear to be adversarial to LC. For example, an overly standardised process and products tend to be an obstacle to the LC principle of continuous improvement. Even though traditional construction practices of the Talensis might have evolved over the years, most of these indigenous practices remain static over a long period of time without conscious efforts towards continually improving to enhance value delivery. The current sporadic permeation of so called contemporary construction materials and technologies in the Talensi area is generally out of context with the physical and social environmental settings of the area and cannot be said to be an improvement on the indigenous building systems. A more socially and environmentally responsive cycle of improvement of the traditional building practices would have been more appropriate and sustainable.

It is worthwhile noting that even though this study focused on the indigenous building culture of the Talensis, some of the findings could be extended to other parts of Ghana and Africa as whole. Notwithstanding the fact that there are occasional peculiarities, the established practices of the Talensis are generally a representation of what happens in most parts of northern Ghana and other parts of Africa, such as Burkina Faso and Mali (Prussin, 1974). The kinship spirit that drives collaboration, standardised forms and materials, as well as sustainable systems can all be traced among indigenous groups in other parts of Ghana and Africa.

Admittedly, the originality of indigenous construction practices among the Talensis has been compromised. This results from the spread of other cultures and practices, especially with the advent of globalisation, to the Talensi area. The kinship spirit that translates to a commitment to shared values in the house-building process is gradually diminishing. The drive behind participation and collaboration has gone beyond the non-economic incentive of social ties to monetary incentives. Focus has also shifted from the use of non-permanent and organic systems to permanent systems and materials such as sandcrete blocks, metal roofing sheets and synthetic finishes. This makes the so-called contemporary buildings less responsive to the social and environmental dictates of the area. There is therefore a need to regenerate the identified traces of LC, identifiable with the indigenous building cultures in Ghana and Africa, to serve as a medium for lean diffusion in Ghana and the rest of Africa.

CONCLUSIONS

LC involves practices in the design and construction of buildings to reduce waste and maximise value for users. Although LC is primarily believed to have evolved from the Toyota production system, this article sought to illuminate traces of LC practices in the indigenous building culture of the Talensi. It has been demonstrated that collaboration, standardisation and sustainability are some of the dimensions in which LC practices can be traced in the traditional building practices of the Talensi. Even though the geographic spread of LC implementation is generally seen as low, especially among countries such as Ghana, the article provides an impetus to explore and regenerate some building practices in antiquity towards diffusing and implementing LC.

The exercise of tracing elements of LC in an African indigenous construction practice was not an attempt to over-simplify or downgrade the concept of LC, though LC is regarded as a contemporary concept in construction project delivery. The exercise rather sought to present LC as a cultural and social phenomenon that requires organisational acceptance. Undoubtedly, technology and physical infrastructure are essential for LC implementation, but the effectiveness of this infrastructure depends on an organisational orientation towards the foundational LC soft elements of respect for people, shared values, transparency, trust and team spirit.

Even though the diffusion of LC within Africa still remains emergent, the findings of this research indicate that LC, as a concept, is not necessarily remote from the social and cultural context of Africa. Some of the elements of LC are found to be embedded in the traditional social and cultural fabric of Africa. Therefore, rather than viewed as an alien and sophisticated concept, traditional African systems and norms could be revived and regenerated to provide a fertile foundation for the implementation of the LC concept on the continent.

REFERENCES

Ayarkwa, J., Agyekum, K., Adinyira, E. and Osei-Asibey D. (2012). Barriers to successful implementation of lean. *Journal of Construction*, 5 (1), 3-10.

Bantowsky, M. (2007). Washington lean and environment project - Final report: *Washington State Department of Ecology*, Publication Number: 07-04-033, Revised. September 2008.

Cardinall, A.W. (1920). *Natives of the Northern Territories of Gold Coast: Their customs, religion and folklore*. London: E.P. Dutton.

Creswell, J. W. (1998). *Qualitative inquiry and research design: Choosing among five approaches*. Los Angeles: Sage Publications.

Darrington, J.W. and Howell, G.A. (2010). An optimized project requires optimized incentives. *Proceedings of the of the 18th Annual Meeting of the International Group for Lean Construction* (IGLC). Haifa, Israel.

Forbes, L. H. and Ahmed, S. M. (2011). *Modern construction: Lean project delivery and integrated practices.* Boca Raton: Taylor & Francis Group.Fortes, M. (1945). *Dynamics of clanship among the Tallensi*. London: Oxford University Press.

Fortes, M. (1949). *The web of kinship among the Tallensi*. London: Oxford University Press.

Gibb, A.G.F. and Isack, F. (2001) Client drivers for construction projects: Implications for standardization. *Engineering, Construction and Architectural Management,* 8(1), 46-58.

Golzarpoor, H. and González, V. 2013. A green-lean simulation model for assessing environmental and production waste in construction. In:C.T. Formoso and P. Tzortzopoulos, (Eds.). *Proceedings of the 21th Annual Conference of the International Group for Lean Construction,* Fortaleza, Brazil. 31 August – 2 September. pp. 885-894.

Höök, M. (2008). Lean culture in industrialized housing: A study of timber volume element prefabrication. A dissertation submitted to Luleå University of Technology in Luleå, Sweden for the award of a doctoral degree.

Howell, G. and Ballard, G. (1998). Implementing lean construction: Understanding and action. *Proceedings of 6th Annual Conference of the International Group for Lean Construction.* Guaruja, Brazil.

Koskela, L. (1992). Application of the new production philosophy to construction. *Technical Report No. 72*, pp. 35. Lean Construction Institute, Stanford, CIFE, Stanford University. Available at: http://www.leanconstruction.org/about.htm

Koskela, L. (2015). Where rhetoric and lean meet. *Proceedings of the 23rd Annual Conference of the International Group for Lean Construction.* Perth, Australia. 29-31 July. pp. 527-535.

Kpamma, Z. and Adjei-Kumi, T. (2011). Management of waste in the building design process: The Ghanaian consultants' perspective. *Architectural Engineering and Design Management,* 7(2), 102-112.

Lichtig, W.A. (2005). Sutter Health: Developing a contracting model to support lean project delivery. *Lean Construction Journal*, 2(1), 105-112.

Liker, J. E. (2004). *The Toyota way*. New York: McGraw-Hill.

McConaughy, T. and Shirky D. (2013*).* Subcontractor collaboration and breakdowns in production: The effects of varied LPS implementation. *Proceedings of the 21st Annual Conference of the International Group for Lean Construction (IGLC). Fortaleza, Brazil.* 29 July – 2 August.

Mathieu, J. E., Heffner, T. S., Goodwin, G. F., Salas, E. and Cannon-Bowers, J. A. (2000). The influence of shared mental models on team process and performance. *Journal of Applied Psychology,* 85(2), 273-283.

Ogunbiyi O., Goulding, J. S. and Oladapo A. (2014) An empirical study of the impact of lean construction techniques on sustainable construction in the UK. *Construction Innovation*, 14(1), 88 – 107.

Ohno, T. (1988). *Toyota production system: Beyond large scale production*.Cambridge, MA: Productivity Press.

Pasquire, C.L. and Gibb, A.G.F. (2002). Considerations for assessing the benefits of standardisation and pre-assembly in construction. *Journal of Financial Management of Property and Construction*, 7(3), 151-161.

Prussin, L. (1974). An introduction to indigenous African architecture. *Journal of the Society of Architectural Historians*, 33(3), 182-205.
Rybkowski, Z. K., Abdelhamid, S. T. and Forbes, L. H. (2013). On the back of a cocktail napkin: An exploration of graphical definitions of lean construction. *Proceedings of the 21st Annual Conference of the International Group for Lean Construction (IGLC).* 29 July – 2 August.
Santorella, G. (2011). *Lean culture for the construction industry: Building responsible and committed project teams*. Boca Raton: Taylor & Francis Group.
Schottle, A. and Gehbauer, F. (2012). Incentive systems to support collaboration in construction projects. *Proceedings of the 20th Annual Conference of the Internationall Group for Lean Construction (IGLC).* San Diego.
Schreckenbach, H. and Abankwa, J.G.K (1983*). Construction technology for a tropical developing country.* Eschborn, Germany: GTZ.
Tam V.W.Y., Tam, C.M., Zeng, S.X. and Ng, W.C.Y. (2007). Towards adoption of prefabrication in construction. *Building and Environment* 42, 3642-3654.
Womack, J. P. and Jones, D. T. (2003). *Lean thinking: Banish waste and create wealth in your corporation.* New York: Simon and Schuster.
Wentworth, J. (2012). Seeking sustainability. *Post Note Number 408*. London: The Parliamentary Office of Science and Technology.

THE PROSPECT OF MINIMISING PRODUCTION FLOW WASTE ON CONSTRUCTION SITES IN NIGERIA THROUGH THE LAST PLANNER® SYSTEM

Emmanuel Itodo DANIEL[1], Christine PASQUIRE[2] and Oko John AMEH[3]

[1]Department of Construction Management and the Built Environment, Southampton Solent University, UK., Email: Emmanuel.daniel@solent.ac.uk
[2]Centre for Lean Projects, Nottingham Trent Univeristy, UK., Email: Christine.pasquire@ntu.ac.uk
[3]Department of Building, University of Lagos, Nigeria., Email: oameh@unilag.edu.ng

ABSTRACT

Poor performance of construction projects is a re-occurring problem in Nigeria. Production flow waste (ranging from waiting time, material handling and over-production, among others) may be partly responsible for this problem. Meanwhile, very little is known about the role of the Last Planner System (LPS) in minimising production flow waste in Nigeria. The current study examines the manifestation of production flow wastes on Nigerian construction sites, identifies current construction practices that bear resemblance to the LPS, and finally, examines the prospects of the LPS concepts in minimising production flow waste in the corresponding construction projects. A mixed research design that uses a quantitative cross-sectional survey and qualitative-exploratory approach was used in collecting data from construction professionals based in Nigeria. Fifty-one survey responses were received and 10 interviews were conducted. The study reveals various incidences and contributory factors to production flow waste, with the long approval process being the most prevalent. It also identifies current practices that are similar to the LPS practices. The prospect of the LPS in production flow waste management for improved productivity is also explored. The study concludes that the LPS concept has the potential for minimising production flow waste in the construction process and improving productivity in the Nigeria construction industry.

Keywords: construction sites, Last Planner System, production flow waste, non-value adding activities, Nigeria

INTRODUCTION

The construction industry has been identified as one of the industries that generate a high level of waste during their operations. Hindrances to continuous production flow (non-value adding activities) in the construction process such as waiting time, material handling, over-production, inventories, rework, redundant activities and labour movement all constitute waste. According to Koskela (2000), this amounts to about 30% of construction costs. These non-value adding activities are referred to as production flow waste in this study. Nigeria has an active

construction industry. However, its contribution to the nation's gross domestic product (GDP) has not been consistent (NBS report, 2015). For instance, in 2010 the share contribution of the construction sector to the GDP was 2.88% (NBS report, 2015); in 2011, it was 4.1% (Oluwasekeyi, 2011). However, in 2012, there was a decline of 14.86%, making the share of construction contribution to the GDP to stand at 3.05%. The National Bureau of Statistics (NBS) of Nigeria reported that the real growth in the construction section in the first quarter of 2016 stood at a negative 5.37% (NBS report, 2016).

This decline has been attributed in part to numerous ills faced by the industry, which include project management deficiencies, such as cost and time overruns; rework; poor work quality; high life cycle maintenance cost; as well as inadequate attention to safety, health, and environmental issues, among others. To improve the performance of the construction industry, Koskela (2000) suggested that advanced construction should be explored. This refers to production management that encourages improved coordination of the construction flow process, analyses and minimises waste (non-value adding activities), while also maximising value for the end users such as in lean construction.

The LPS developed by Ballard and Howell is a lean construction approach that focuses on reducing workflow uncertainty which was identified as a missing component in the traditional project management kit (Ballard and Howell, 2003). In practice, the LPS stabilises the production (construction) process on a project by identifying relationships, matching them with plans and balancing resources (Mossman, 2014; Ballard and Howell, 2003). The LPS establishes relationships between people, tasks, locations, materials, drawings, time, information, and resources so as to develop a common understanding of the project goals among stakeholders (Pasquire, 2012; Koskela, 2000). This supports the smooth flow of work, collaboration, and commitment from all project participants, thus delivering value for all the stakeholders of the project (Koskela and Ballard, 2006). This implies that the LPS could minimise production flow waste.

The implementation of the LPS has gained prominence in the construction industry and its influence on the production system seems to be rapid and significant (LCI, 2015; Daniel et al., 2015). However, its implementation in the construction industry in Nigeria is still low (Ahiakwo, et al., 2013; Adamu and Howell et al., 2012). There is a dearth in empirical study to understand the prospect of the LPS in minimising production flow waste. It is believed that production flow waste (non-value adding activities) is prevalent on construction projects (Emuze et al., 2014). However, previous studies on construction waste in Nigeria seems to focus more on physical waste on site (Ameh and Daniel, 2013; Ajayi et al., 2011; Wahab and Lawal, 2011), rather than production flow waste.

Furthermore, it is still not clear whether there are current construction practices that show resemblance to the LPS in Nigeria. This could support the future implementation of the LPS in Nigeria. However, previous studies on the LPS in Nigeria were based on a case study, are organisational specific (Adamu and Howell 2012), and are unable to capture current construction practice across the industry that shows a resemblance to the LPS. However, the study reported here cut across the major professionals in the construction industry in Nigeria so as to identify current

practices that show resemblance to the LPS and explore the prospect of the LPS in minimising production flow waste on construction sites. The research question therefore is: How does production flow waste manifest on construction sites in Nigeria? What is the prospect of minimising it using the LPS concept?

This study provides new insights into how production flow waste manifests on construction sites in Nigeria, and shows the potential of the LPS in minimising its occurrence in construction sites for improved productivity. Furthermore, the clear identification of some the current construction practices that show a resemblance to the LPS in Nigeria contributes to future implementation of the LPS in the construction industry in Nigeria.

LITERATURE REVIEW

Previous studies on waste in the Nigeria construction industry

Various studies in the past have examined waste in the Nigeria construction industry. Ajayi et al. (2008) examined waste management practice on construction sites in Lagos, Metropolis and the study found that the increase in waste generation on construction sites is of great environmental concern. Similarly, a study by Oladiran (2009) explored the extent of the use of the Waste Management Plan (WMP) in minimising construction waste in the construction industry in Nigeria. The study reveals that the use of the WMP on construction projects in Nigeria is average. This could mean that not every construction project has a clear WMP in place. Ameh and Daniel (2013) analysed the most commonly used construction operations and material at construction sites. The study found that the most wasteful building material during the execution of construction activities on the site is mortar from plastering and rendering. The study further revealed that building material wastage contributes between 21% and 30% to project cost overrun. However, the study is based on the perception of construction professionals rather that quantitative measurement. Nevertheless, this evidence shows that construction waste occurs in the construction process in Nigeria. A further confirmation of this was a study by Adewuyi and Odesola (2015) who examined the contributory factors to material wastage in the construction industry in Nigeria. The study found that uneconomical cutting of shapes is one of the highest contributing factors to material wastage. It is clear from the review that the focus of previous studies was on physical waste. While it is important to examine physical waste, waste in construction is not limited to physical waste alone. There are other types of waste such as production flow waste, also known as non-value adding activities. According to Koskela (2000), any activities that consume resources and material but do not create value amount to waste. In view of this gap, the current study focused on production flow waste.

Construction production flow waste

There are different views as to what constitutes waste. However, in lean production all non-value adding activities in the production process are termed as waste. Zhao and Chua (2003) identified two major activities that occur in the production flow, namely non-value adding activities and value-adding activities.

According to Koskela (2000), non-value adding activities (waste) "…are those activities that take time, resources or space, but do not add value", while value-adding activities are those activities that convert material and information towards that which is required by the customer.

The Nigerian construction industry is characterised by the growing rate of construction, production flow waste occasioned by delays in project delivery, and rework, among others. Delay occurs when the contractor and the project owner jointly or severally contribute to the non-completion of the project within the agreed contract period. Important causes of delays in Nigeria building projects include the financing of and payment for completed works, poor contract management, design changes, and shortages in resources, among others (Aibinua and Jagboro, 2002; Oyewobi and Ogunsemi, 2010). In a study of 102 building projects in Nigeria, Aibinu and Jagboro (2002) found that the average time overrun associated with delay factors was 92.64% of the estimated project duration for projects below 10 million Naira ($65,000) and 59.23% for projects above this. This is perhaps one of the highest in the world.

On the other hand, Oyewobi and Ogunsemi (2010) assert that 70% of construction projects in Nigeria involve rework, leading to about a 3% to 15% variation of project cost, 40 to 60% labour productivity loss and 10% wastage of materials. In a study of 25 completed projects in Nigeria, the average estimated cost of rework was 3.47%. When broken down, this amounted to 5.06% for a new building, while that of a refurbished building was found to be 3.23% (Oyewobi et al., 2011). This gives an indication of the prevalence of production flow waste on construction sites in Nigeria. In a related study, Oyewobi et al. (2011) observed that finishes are more prone to rework which results in a 19.09% cost and time overrun.

Based on the foregoing, it is evident that production flow waste coupled with corruption and unethical practices (Oyewobi et al., 2011; Olusegun et al., 2011) makes the cost of construction in Nigeria one of the most expensive in sub-Saharan Africa. According to Thomas et al. (2002), the essence of eliminating or minimising non-value activities from the production process is to create better value for the consumer. Several sources of non-value adding activities have been identified in the literature (Alwi et al., 2002; Zhao and Chua, 2003; Ralph and Iyagba, 2012). Some of these could manifest in the form of waiting time for instruction, unclear shop drawings, poor quality site documentation, poor design, design changes, slow drawing revision, unclear specification, poor coordination among project participants, poor planning and scheduling, unreliable equipment, late delivery of material to the site, and weather conditions.

Koskela (2000) classified these non-value activities based on their root causes into the following three groups: the structure of the production system, the way production is controlled, and the inherent nature of the production. Figure 1 presents production flow waste as identified in the literature.

Table 1: Production flow waste

Production flow waste	Reference
Long approval process	Alwi (2002); Zhao and Chua (2003); Al-Aomar (2012)
Inadequate project planning	Daniel et al. (2014); Koskola, (2000); Alwi et al. (2002); Aiyetan and Das (2015).
Equipment breakdown	Alwi et al. (2002); Ralph and Iyagba (2012)
Design changes	Ralph and Iyagba (2012)
Waiting for inspection	Aiyetan and Das (2015); Ralph and Iyagba (2012)
Congestion on site	Zhao and Chua (2003)
Waiting for another crew to complete their work	Awi et al. (2002)
Delay from suppliers	Awi et al. (2002)
Excessive transport of material	Zhao and Chua (2003);
Construction error	Aiyetan and Das (2015)
Rework	Aiyetan and Das,(2015); Zhao and Chua (2003);
Waiting for instruction	Zhao and Chua (2003)
Excessive labour movement	Ralph and Iyagba (2012); Awi et al. (2002)
Waiting for equipment	Zhao and Chua (2003)
Dispute and disagreement on site	Awi et al. (2002)

The Last Planner System of production control

The Last Planner System is a production planning and control technique developed in the 1990s for the construction industry. It supports the development of collaborative relationships among those doing the work (Daniel et al., 2017; Ballard, 2000). According to Daniel et al. (2017) and Papke and Dove (2013), the LPS is a production planning and management methodology for construction. In the LPS approach of managing project production, "planning" and "control" are integrated: however, in the traditional approach of managing project production, "planning" is separated from "control" (Ballard and Howell, 2003; Ballard, 1997).

The LPS supports collaborative planning among construction stakeholders.

The influence of the LPS in managing the production process in construction has been retrospectively rationalised through theories relating to decision-making and uncertainty in the production process (Ballard et al., 2009). Notable among these theories are the Transformation-Flow-Value theory (Koskela, 1992; Koskela and Ballard, 2006); and the language/action perspectives (Flores, 1982; Hayek, 1945) which posited that the knowledge needed for planning is dispersed among individuals. More importantly, the underlying theories of the LPS revolve around planning, execution, and control. According to Ballard and Howell (2003), the LPS focuses on planning and production control which is opposed to monitoring in the traditional project management approach. The five key principles of the LPS (Ballard et al., 2009) are (1) ensuring tasks are planned in increasing detail the closer the task approaches the execution phase even before the task commences; (2) ensuring tasks are planned with those who are to execute them; (3) identifying constraints on planned task which should be removed by the team beforehand; (4) ensuring promises are secure and reliable; and (5) continuous learning from failures that occur when executing tasks to prevent future reoccurrence. These five initial principles have been extended to twelve in the recently published *Current Process Benchmark for the LPS* (Ballard and Tommelein, 2016).

The LPS comprises five basic elements: (1) the master programming, (2) phase scheduling/collaborative programming, (3) the look-ahead planning, (4) a weekly work planning (WWP) meeting, and (5) measurement and learning (Mossman, 2014; Ballard, 2000). It has been observed that the implementation of these elements could minimise production flow waste and improve project performance. For instance, measurement of Percent Planned Complete (PPC) which is one of the metrics of the LPS enables the project team to identify the reliability of their plan over time. According to Lim et al. (2006), measuring PPC is the performance management system for the LPS. Ballard (1997) asserts that PPC measurement supports continuous improvement as it allows the team to learn from the reason for non-completion postulated at the WWP meetings which are part of the PPC measurement process. This implies that the PPC measurement does not show plan reliability alone, but also other project performance indicators. For instance, Koskela et al. (2010) and Liu and Ballard (2008) observed that PPC measurement and the LPS generally improve productivity and thus cost reduction. This suggests that the implementation of the LPS in the building industry in Nigeria would improve the productivity of the sector.

The Last Planner(s) "…is the person or group that makes assignments to direct workers" (Ballard, 2000, G-14). Last Planners do not only do the work, but are also actively involved in developing the programme of work and ensuring work is made ready before being sent to the work phase (Mossman, 2014; Adamu and Howell, 2012). The duties of Last Planners, therefore, are to ensure that work is planned efficiently to create flow in the construction process and to ensure such work is executed at the optimal level. The Last Planner System process is based on five major processes and these have been explained in previous publications (Ballard and Tommelein, 2016; Mossman, 2014; Ballard, 2000).

Some practices associated with the LPS include weekly work coordination

meetings; weekly workload allocation; weekly review meeting with subcontractors (Daniel et al. 2017; Mossman, 2014 Ballard, 2000); investigating why what has been planned is not completed; a system to monitor improvement in the work executed; accepting suggestions from subcontractors; devising a back-up plan; having a collaborative meeting that allows the client, main contractor and subcontractor to communicate effectively; and team-based planning that uses reverse phase scheduling (Daniel et al., 2017; Ballard and Tommelein, 2016; Mossman, 2014; Ballard and Howell, 2004; Ballard, 2000).

The Last Planner System in Nigeria

Recent research has revealed that the LPS has been implemented in over 16 countries, including Nigeria (Daniel et al., (2015). The earliest study on the LPS in Nigeria was a research study that reported the implementation of the LPS in a public housing project (Adamu and Howell, 2012). The study found that the introduction of the LPS methodology led to faster delivery of more housing units within the given time compared to the housing units where the LPS approach had not been used. This shows that the LPS supports faster project delivery in Nigeria. However, the study reveals that the study participants were not familiar with the LPS. Similarly, Ahiakwo implemented the LPS on a road construction project in Nigeria (Ahiakwo, et al., 2015). The study found that the implementation of LPS contributed to production stabilisation and improvement in programme reliability.

Other benefits realized from the LPS on the above project include a reduction in bad news, on-time completion of the project, a predictable and workable work plan, improved logistics, and a reduced management workload, amongst others. The above findings show that the benefits of LPS implementation in Nigeria are similar to those reported in other parts of the world (Fernando-Solis et al., 2012; Mossman, 2014; Alsehaimi et al., 2009). According to Mossman (2014), bad news early is good news in the LPS approach of managing construction project. This is so because it allows the team to plan and address bad news early. Even with these benefits, there are challenges facing LPS implementation in Nigeria. These include cultural issues and resistance to change, lengthy approval processes, and issues with subcontractors, amongst others (Ahiakwo et al., 2015).

RESEARCH METHODOLOGY

A mixed research design that employed a quantitative cross-sectional survey and qualitative-exploratory approach was used in collecting data from Nigerian construction professionals dispersed across the country. The use of the mixed approach in construction management research has been widely reported in literature (Dainty, 2008). In this study interviews and a survey approach were used to complement each other. The survey instrument was divided into four major sections. The first section sought to know the respondents' background information to validate the reliability of the responses. Section two sought to determine the frequency of occurrence of 15 sources of production flow waste identified from the literature review (Aiyetan and Das, 2015; Emuze et al., 2014; Ralph and Iyagba, 2012; Alwi et al., 2002; Zhao and Chua, 2003). The respondents were also asked to rank some encountered construction practices associated with the LPS as identified from

literature (Daniel et al., 2017; Ballard and Tommelein, 2016; Ballard et al., 2009; Chee et al., 2009; Ballard, 2000). However, these practices were rephrased to facilitate the respondents' understanding. This was done since most of the respondents are not familiar with the technical terms associated with the LPS principles and concepts. The five-point Likert scale was used, with five (5) being the highest and one (1) the least on the scale.

The questionnaires were administered via email to construction professionals in Nigeria who are registered with their professional bodies and have valid email addresses in the online database system. These professional bodies include the Nigerian Institute of Quantity Surveyors, the Nigerian Institute of Civil Engineers, the Nigerian Institute of Architects and the Nigerian Institute of Building. The respondents hold various positions such as construction managers, project managers, quantity surveyors, site managers, project architects, and structural engineers, among others, and they are based in different parts of the country. Construction professionals from academia also participated in the study.

A total of 110 questionnaires were distributed and only 51 responses were received. This represents an aggregate response rate of 46%. Ten (10) respondents participated in the open-ended semi-structured interviews. They comprise five main contractors, three consultants and two academics (See Table 2 for the profile of the interviewees). The open-ended interview questions allowed the respondents to speak their mind on the subject under investigation. The interviews were recorded and transcribed. The results from the surveys and interviews are presented in the next section.

Table 2: Interviewees' profiles

Respondents	**Position**	**Years of experience in Nigerian construction**
Main contractor 01	Project coordinator/Researcher	15
Main contractor 02	Project engineer	20
Main contractor 03	Site engineer	10
Main contractor 04	Construction manager	12
Main contractor 05	Senior project manager	25
Consultant 02	Senior engineer	20
Consultant 03	Project engineer	15
Consultant 04	Resident engineer	22
Academia 01	Senior lecturer	23
Academia 02	Lecturer	10

FINDINGS AND DISCUSSION

Respondents' organisation background

The details of the respondents indicate that 62.5% are from contracting organisations, 20% from consulting and 17.5% are from academia. This shows the responses were not limited to the construction site professionals alone, but also included the consultants and those in academia. This means the study benefits from the current academic knowledge of researchers on non-value adding activities and Last Planner practices. Furthermore, since the majority of the respondents are from contracting organisations, they should be able to provide reliable data for the study considering that non-value adding activities and any means to minimise these will be of interest to them. In terms of respondents' experience in the Nigerian construction industry, the result showed that 70% had over five years of experience. This implies that the respondents have sufficient construction experience in Nigeria, thus information obtained on production flow waste can be adequately relied upon.

Analysis of production flow waste in Nigeria

The study sought to determine the frequency of occurrence of some identified sources of production flow waste from the literature. The factors were measured on a five-point Likert scale ranging from 'very frequently' to 'not all'. Figure 1 shows the results of the analysis of production flow waste in Nigeria.

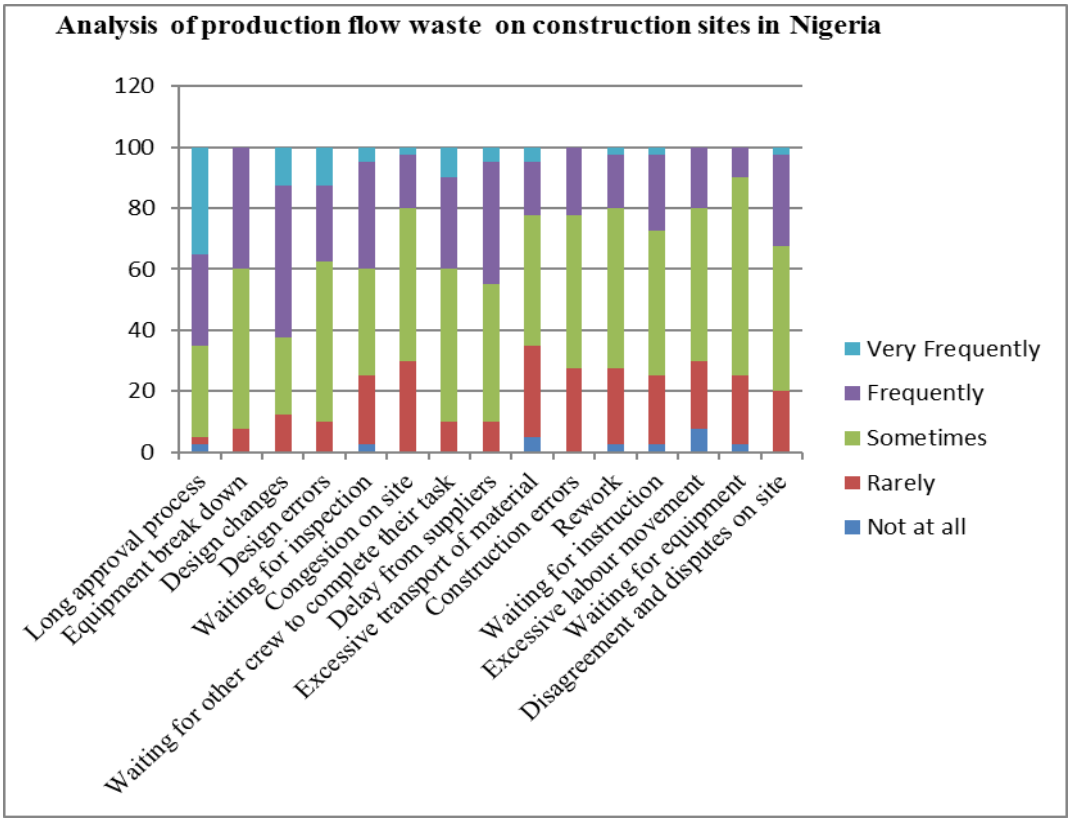

Figure 1: Analysis of production flow waste on construction sites in Nigeria

As shown in Figure 1, it is evident that production flow waste is a common occurrence on construction sites in Nigeria. The result revealed four significant sources of ? production flow waste that occur most frequently in the construction process on sites in Nigeria. They include a long approval process, design changes, design errors, and waiting for another crew to complete their task. Earlier studies such as those by Alwi (2002), Zhao and Chua (2003) and Ralph and Iyagba (2012) also identified waiting for instructions, design changes, design errors, and waiting for other crews to complete their work to be among the factors that affect production workflow on site. This study found that the long approval process is the most frequent cause of production flow waste in the Nigerian construction industry. This finding is consistent with similar findings in a study in Abu Dhabi by Al-Aomar (2012) in which long approval processes ranked second among the top ten waste types in the Abu Dhabi construction industry. Aiyetan and Das (2015) also found that design-related issues contribute to production flow waste on projects in Nigeria. Again, the frequent occurrence of long approval processes in the Nigerian construction industry could be attributed to bureaucratic bottlenecks, especially with public projects; the demand for 'kick backs (bribery); and the lack of transparency and trust in the procurement process (Olusegun et al., 2011; Oyewobi et al., 2011). According to Olusegun et al. (2011), the absence of a clearly defined project scope and the underpayment of consultants in Nigeria contribute to kick back practices. Oyewobi et al. (2011) found that corruption in Nigeria contributes to delays in project approval. This could mean those in the approval process could contribute to this as well since it takes people to cause delays.

To further support this view, the ongoing debate within the International Group for Lean Construction research community put forward a proposal to view bribery and corruption as waste in the construction industry (Stifi et al., 2014). The study suggests that the LPS could be a means of overcoming bribery and corruption in the construction industry because of its potential to support transparency and the development of collaborative relationships among construction stakeholders.

Furthermore, the frequent design changes could be attributed to inadequate project scope definition, the procurement option adopted and constant interference from the client. In Nigeria the most frequently used procurement route is the traditional approach (Ojo et al., 2006). However, drawings are never completed before the commencement of work on site and even when drawings are completed, scope creep and variations due to site challenges may necessitate changes. Morledge et al. (2006) argue that clients are largely responsible for most of the changes that occur to satisfy their needs during construction on sites.. Zhao and Chua (2003) found that project-related factors such as external factors, project features, design features, organisational factors, and management factors influence the occurrence of production flow waste on site.

The impact of these five main causes of production flow waste on productivity and performance improvement in the Nigeria building construction industry cannot be underestimated. There is a need to minimise production flow waste in construction, which can be achieved by adopting lean techniques such as the LPS (Adamu and Howell, 2012). In reality, production flow waste does not only

contribute to cost and time overrun, but also leads to accidents on the site and the underutilisation of human resources on the site (Ralph and Iyagba, 2012). Currently, the productivity loss in the Nigerian construction industry is high. According to Oyewobi and Ogunsemi (2010), loss in labour productivity in Nigeria is in the range of 40% to60%. However, Alarcon et al. (2005) assert that the application of the LPS on some case study projects resulted in an 86% improvement in productivity.

Current planning practices in Nigeria that resemble LPS

The study investigated current site practices that indicate Last Planner practices. The respondents were required to indicate how often they adopted or observed some identified practice that shows a resemblance to the LPS practice by responding to the five-point Likert scale, ranging from 'not at all' to 'very frequently'. The results of the analysis are presented in Figure 2.

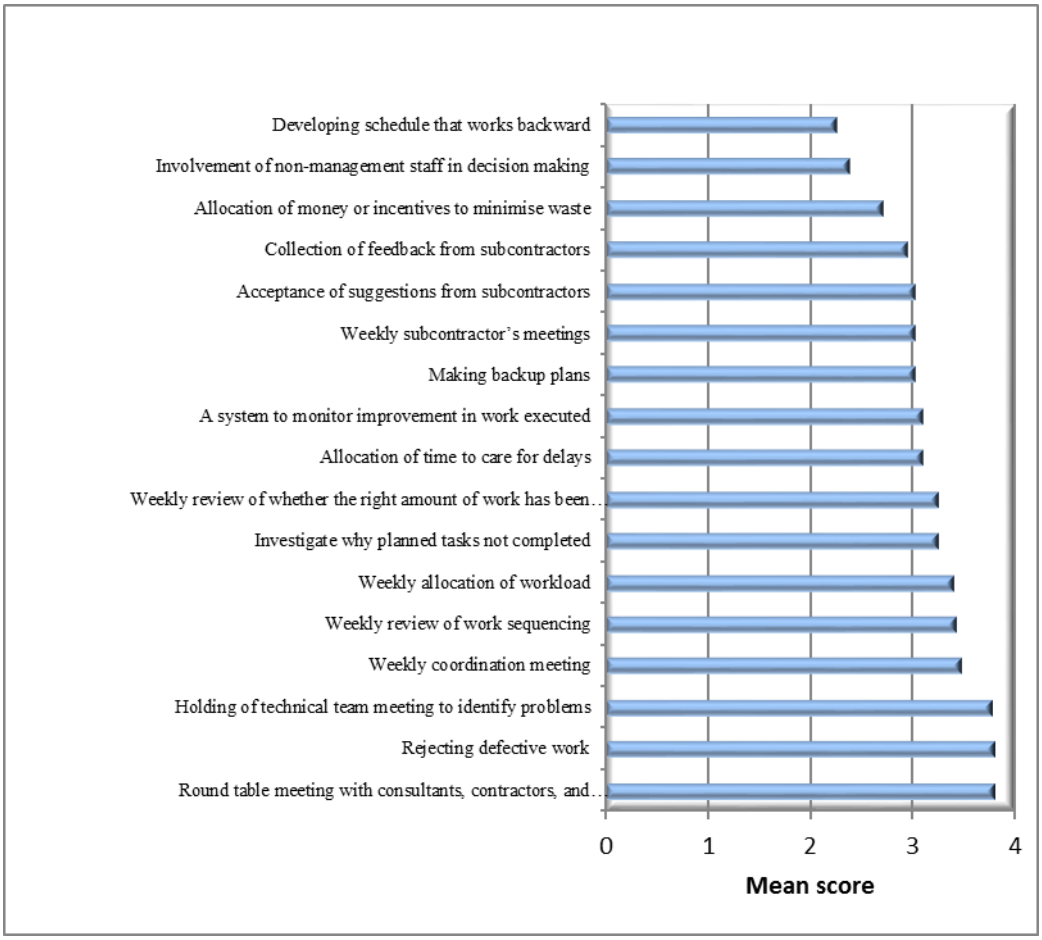

Figure 2: Current planning practices in Nigeria that resemble LPS

The study reveals two frequently used practices that resemble the Last Planner practices indicated in the literature. They include round table meetings with clients,

consultants, contractors and subcontractors and the holding of weekly technical meetings. Having round table meetings with the key stakeholders could be linked to the phase planning or collaborative programming meetings in the LPS (Ballard and Howell, 2003; Ballard, 2000). In the LPS, the phase planning session enables key project participants to agree on the interphase between each activity in the master programme, known as the milestone programme in the LPS, and to agree collaboratively on activity durations. Additionally, the technical meetings frequently held for resolving problems could serve as a platform for carrying out the "five whys" analysis in the LPS process to resolve problems in the production process (Ballard and Howell, 2003).

Since the majority of the respondents claimed to have frequent meetings with clients, consultants, contractors and subcontractors, this could help in encouraging collaboration among the project participants, thus creating a better platform for the implementation of the entire Last Planner System on the project for better outcomes. Researchers have shown that the Last Planner System even helps in managing complex relationships among project team members at all levels for the optimal delivery of the project outcomes (Daniel et al., 2017; Mossman, 2014; Ballard and Howell, 2003). More importantly, when the complex relationship that exists among construction stakeholders is properly managed, this will further reduce production flow waste that might arise during the construction process on site, thus improving productivity and performance. Research has shown that the LPS approach can be used to reduce uncertainty and to create flow in the production process since it has the potential of relating project scheduling with planning, thus enhancing good workflow and reducing variability in the production system (Fernandez-Solis et al., 2012; Ballard and Howell, 2004; Salem et al., 2006).

In addition, the analysis reveals twelve other current practices that resemble the Last Planner System practices and that are sometimes adopted by the respondents. Although these practices are not observed or adopted regularly on construction sites now, the study has shown that such practices already exist in the construction process on sites in Nigeria. This could serve as a good platform for the full implementation of the Last Planner System on construction sites in Nigeria. For instance, Hamzeh and Bergstrom (2010) suggest that for better implementation of the Last Planner System, a framework that encourages teamwork and continuous improvement should be developed by the organisation. Fuemana (2013) asserts that when the LPS is properly implemented, it improves project performance and also increases productivity. However, LPS implementation is still low in the Nigerian construction industry, as only two studies have reported its implementation on case study projects (Adamu and Howell, 2012; Aihaikwo et al., 2013). This implies that for the Nigeria construction industry to benefit from the productivity improvement achievable through the LPS, industry-wide adoption is essential. It is worth noting that even in developed countries industry-wide adoption of the LPS does not exist yet (JØrgensen et al., 2004; Mossman, 2009; Johansen and Walter, 2007).

On the other hand, the study reveals two Last Planner practices that were seldom used in the current practice in the Nigeria construction industry. They include developing schedules that work backwards and involving non-management staff in decision-making. The implication of this is that construction managers, project

managers, site engineers, and site managers may not involve site operatives such as foremen in their planning and decision-making processes on site. This could lead to the generation of more production flow waste on site, since the common understanding needed to create flow in the construction process is absent (Pasquire, 2012). Pasquire (2012) proposed the eighth flow, known as the "common understanding", as one of the pre-conditions that need to be met for smooth work flow in the production process. The danger of not involving all the required stakeholders in the planning process is that it would be difficult to gain their input and commitment to the plan. This will always occur when the plan is thrown at them to perform it. Ballard (2000) argued that in order for site operatives to make reliable promises and be committed to carrying them out, they must be involved in the planning and decision-making process.

The manifestation of production flow waste on construction sites - interview results and discussion

The respondents interviewed were asked to identify how production flow waste manifests on construction sites and the factors that contribute to it. One of the interviewees identified the inconsistent use of site operatives that results in error and rework, and bringing equipment to site when not needed due to the over-ambition of contractors' project managers. The frequent change of site operatives could be due to the nature of construction projects. Over the years the construction industry has been identified as one of the sectors that keeps hiring and firing its workforce, thus resulting in low employee retention (Aguenza et al., 2012). However, research by the Construction Industry Institute has shown that contractors with an employee retention of rate of 80% complete projects on time and record better project performance (Ramos, 2014). This could be due to the common understanding the workers or site operatives develop from working with one another over a period of time. Similarly, another research participant stated that:

> "*In Nigeria we disagree to agree dispute and disagreement on site, delay in transporting material to site and waiting for equipment are among the most common incidences of production waste flow on site*" [Resident engineer].

The delay in waiting for material and equipment could be due to a lack of adequate planning of the production process. For example, in the LPS this problem can easily be addressed in the lookahead planning and in the make work ready meetings, where provisions are made for tasks to be properly screened before moving into the work phase (Ballard and Tommlein, 2016; Ballard and Howell, 2003). Furthermore, a construction manager working for a contracting organisation observed that long approval processes and the excessive use of inexperienced workers contribute to production flow waste on construction sites in Nigeria. The interview results affirmed the findings of the questionnaire survey on the manifestation of production flow waste on construction sites in Nigeria. Other factors identified as contributory factors to production flow waste by the interviewees include a lack of adequate planning, a lack of team work, disturbance from the local community, and not allowing enough time for planning before the commencement of work on site, among others.

The study reveals that all the respondents agreed that the lack of adequate planning and the use of inexperienced workers contribute to the incidence of production flow waste on site. It is worth noting that the occurrence of any of this waste has a cumulative effect on the production process. When one operation is delayed, it will affect the entire production or construction process, thus leading to a lack of flow in the entire process and an increase of production flow waste (Koskela, 1999; Ballard, 2000). The occurrence of these causes of production flow waste on site will no doubt negatively affect the productivity and performance improvement on site in Nigeria. However, these can be addressed through proper planning based on the LPS principles. Research has shown that value can be created through proper planning and defining what every tradesman or operative on site is required to achieve using the LPS principles (Ballard and Tommelein, 2016; AlSehaimi et al., 2014; Ballard, 2000). This could help in eliminating rework and error, among others, thus improving productivity on site.

Current planning and control practice and the LPS practice-interview results and discussion

The interviewees were asked to describe the current planning and control practice on their projects. One of the study participants, a project engineer, stated that:

> *"Currently we adopt the following planning and control measures on our projects; material delivery schedules, planning work weekly, checking of the quality of work done and motivation of workers*".

The above statement shows that there are approaches used in the planning of construction activities on the site. However, the lists tend to show that the planning and control measures are more of a stand-alone process rather than an integrated approach. In the LPS planning and controlling of the production system is seen as an integrated process (Ballard and Howell, 1997). However, another main contractor, a project engineer and researcher who claimed to be knowledgeable in lean construction as a result of his research, stated that:

> *"We create time for various meetings such as 6 weeks lookahead planning with project team, constant planning and review of work with other stakeholders, and early meeting to address problems with the project. Through this planning approach we were able to reduce wasteful processes on the project.* "

When asked whether his knowledge of lean construction had in any way influenced the current practice, he said, "Definitely, yes! I didn't do this many years ago with my worker[s], but now enjoy doing it". Again, this shows the importance of having awareness and knowledge of lean construction principles and understanding its potential in reducing waste and improving productivity. However, the research shows that there is no formal procedure for doing this across the industry.. Furthermore, the interview results revealed that the planning strategies used reduced

wasteful processes on site. The respondent explained that the six weeks' lookahead planning and weekly work review with those doing the work enabled the team to deliver a task as planned. Koskela (1997, 2000) found that non-value adding activities could be minimised through effective planning and control of the construction process. This means effective planning and control would reduce production flow waste on site.

Prospect of minimising production flow waste through the LPS

The research participants were asked to identify how to minimise production flow waste on construction sites. A respondent, a senior lecturer, suggested that team work, early involvement of subcontractors, good project planning, good communication among the different operatives, discipline among site operatives, visual management and simulation using 3D, and stakeholder management would minimise production flow waste on site.

Similarly, another respondent, a construction manager, proposed that production flow waste can be minimised by "putting into practice what is planned", using trained and qualified site operatives, communicating and collaborating among workers on site, constantly monitoring and checkingplans, working in one room to reduce waiting time, and being disciplined in the use of the planning approach. Other measures for minimising production flow waste on site suggested by other respondents include encouraging team working among project teams, training and proper scheduling of work by professionals, constant reviewing work, and creating effective coordinating units in the organisation. All ten respondents interviewed firmly believed that effective planning, team work in planning, frequent reviewing work and planning ahead can minimise the incidence of production flow waste.

Some of the approaches suggested by the respondents as a means for minimising production flow waste can be matched with some LPS and lean construction principles. For instance, some of the respondents suggested effective planning and collaborative approach in planning, team working in planning, frequent reviewing the plan, constant monitoring, checking, using one single room, and communicating with other workers on the project, among others. Studies have found that production flow waste can be minimised through a systematic planning approach, such as allowing work to commence at optimal conditions, reducing task variability risk, emphasizing continuously improving task execution, avoiding loss of time in the production process and encouraging team work (Koskela, 1999; Howell and Ballard 1998).

This implies that LPS has the potential to minimise production flow waste in the construction process because of its ability to reduce uncertainty and risk inherent in the production process (Howell and Ballard, 1998). However, the traditional approach to planning based on the critical path method (CPM) lacks the capacity to manage the uncertainty inherent in the production process on site (Khanh and Kim, 2014). It has been observed that the inability of the traditional planning approach to manage the uncertainty in the production process on site is among the major contributory factors to production flow waste on site and the low predictability of engineering projects (Daniel et al., 2014; Khanh and Kim, 2014).

CONCLUSIONS AND RECOMMENDATIONS

The purpose of the current study was to determine how production flow waste manifests on construction sites and explore the prospect of minimising production flow waste and improving productivity on construction sites in Nigeria using the Last Planner System practice. The study has identified that production flow waste is prevalent in the construction process, based on the consensus of Nigerian construction industry professionals' perceptions. It manifests in various forms with long approval processes, design changes, design errors, and waiting for other crews to complete their task being the most prevalent. In addition, factors such as the use of inexperienced site operatives, lack of adequate planning, lack of team work, and frequent changing site operatives are among the factors that contribute to the occurrence of production flow waste on site.

The study found that there are practices in the Nigerian construction process that show resemblance with the Last Planner such as having frequent round table meetings between main contractors and subcontractors, holding frequent technical meetings to review problems, and having lookahead meetings and weekly review meetings with project team members. However, there is no formal procedure for doing this across the business and the meetings are also unsystematic. Nevertheless, the findings confirmed the presence of some elements of LPS practice adopted in the construction process which could be used as a basis for the implementation of the Last Planner System.

The study found that some of the measures suggested for minimising production flow waste on the construction site reflect some LPS principles. The measures suggested include adequate planning, team work in the planning of tasks, constantly reviewing work, communicating effectively among the different operatives, maintaining discipline among site operatives, and creating an effective coordinating unit. These suggestions demonstrate that the LPS has the potential to minimise production flow waste on construction sites in Nigeria, thus improving the sector performance and productivity.

The study concludes that the LPS has the potential to minimise production flow waste on construction sites in Nigeria and recommends that, since the structure for the LPS is on the ground, and its benefits have been reported, Nigerian construction professionals should embrace the full implementation of the LPS. A limitation of this study is that the majority of the evidence is based on the construction phase. A future study could explore the application of the LPS in the design and pre-construction stages.

REFERENCES

Adamu, I. and Howell, G. (2012). Applying Last Planner in the Nigerian construction industry In: I.D.Tommelein and C.L. Pasquire (eds.). *Proceedings of the* 20th *Annual Conference of the International Group for Lean Construction*. San Diego, USA. 18-20 July.

Aguenza, B.B. and Som, A.P.M. (2012). Motivational factors of employee retention and engagement in organizations. *International Journal of Advances in Management and Economics*, 1(6),88–95.

Ahiakwo, O., Oloke, D., Suresh, S. and Khatib, J. (2013). A case study of Last Planner System implementation in Nigeria. In: C.T. Formoso and P. Tzortzopoulos (Eds.). *Proceedings of the 21th Annual Conference of the International Group for Lean Construction.* Fortaleza, Brazil. 31-2 August. pp. 699-707.

Ahiakwo, O., David, O., Suresh, S. and Khatib, J. (2015). Implementing the Last Planner ® System in a road construction project in Nigeria. *Built Environment Journal*, 12 (2), 33-49.

Aibinu, A. A. and Jagboro, G. O. (2002). The effects of construction delays on project delivery in Nigerian construction industry. *International Journal of Project Management*, 20(8), 593-599.

Aiyetan, O. A. and Das, D. (2015). Using system dynamics modelling principles to resolve problems of rework in construction projects in Nigeria. *Journal of Construction Project Management and Innovation*, 5 (2), 1266-1295.

Ajayi, O. M., Ogunsanmi, O. E., Ajayi, K. A. and Ofili, M. (2010). Factors affecting the performance of contractors on construction projects in Lagos State, Nigeria. *Proceedings of the Construction, Building and Real Estate Research Conference of the Royal Institution of Chartered Surveyors.* Paris, France. 2- 3 September.

Ajayi, O. M., Koleoso, H. A., Soyingbe, A. A. and Oladiran O. J. (2008). The practice of waste management in construction sites in Lagos state, Nigeria. *Proceedings of the Construction and Building Research Conference of the Royal Institute of Charted Surveyors*. Dublin Institute of Technology. 4-5 September.

Alarcón, L.F., Diethelm, S., Rojo, O. and Calderon, R. (2005). Assessing the impacts of implementing lean construction. *Proceedings of the 13th Annual Conference of the International Group for Lean Construction.* Sydney, Australia. 19-21 July. pp. 387-393.

AlSehaimi, O. A., Tzortzopoulos, F. P. and Koskela, L. (2014). Improving construction management practice with the Last Planner System: A case study. *Engineering, Construction and Architectural Management*, 21(1), -64.

Alwi, S., Hampson, K. D. and Mohamed, S..A. (2002). Non value-adding activities in Australian construction projects. *Proceedings of the 1st International Conference on Advancement in Design, Construction, Construction Management and Maintenance of Building Structure*. pp. 20-34

Ameh, O. J. and Daniel, E.I. (2013). Professionals' views of material wastage on construction sites and cost overruns. *Organization, Technology and Management in Construction: An International Journal*, 5(1),747-752.

Ballard, G. and Howell, G. A. (2003). An update on Last Planner. *Proceedings of the 11th Annual Conference of the International Group for Lean Construction*. Virginia, USA.

Ballard, G. (1997). Lookahead planning: The missing link in production control. *Proceedings of the 5th Annual Conference of the International Group for Lean Construction*. Griffith University, Gold Coast, Australia.

Ballard, G. and Tommelein, I. (2016). Current process benchmark for the Last Planner® System. *Lean Construction Journal*, 57-89.

Ballard, G. and Howell, G. (1998). Shielding production: Essential step in production control. *Journal of Construction Engineering and Management*, 124(1), 11-17.

Ballard, G., Hammond, J. and Nickerson, R. (2009). Production control principles. *Proceedings of the 17th Annual Conference of the International Group for Lean Construction*. 15-17th July. Taipei, Taiwan.

Ballard, H. G. (2000). *The Last Planner System of production control*. A dissertation submitted to the University of Birmingham for the award of a doctoral degree.

Chee, T. M., Raphael, B. and Pheng, L. S. (2009). Lean construction principles and their practice in Singapore. *Construction Information Quarterly*, 11(1).

Dainty, A. (2008). Methodological pluralism in construction management research. *Advanced Research Methods in the Built Environment*, 1-13.

Daniel, E. I., Pasquire, C. and Dickens, G. (2014). Social perspective of planning in construction: The UK experience. *Proceedings of the 30th Annual Association of Researchers in Construction (ARCOM) Conference*, 1-3 September. Portsmouth, UK. pp. 1355-1365.

Daniel, E.I., Pasquire, C. and Dickens, G. (2016). Exploring the factors that influence the implementation of the Last Planner System on joint venture infrastructure projects: A case study approach. *Proceedings of the 24th Annual Conference of the International Group for Lean Construction*. Boston, MA, USA. 20-22 July. pp. 23–32.

Daniel, E.I., Pasquire, C., Dickens, G. and Ballard, G. (2017). The relationship between the Last Planner® System and collaborative planning practice in UK construction. *Engineering, Construction and Architectural Management*, 24 (3).

Emuze, F., Smallwood, J. and Han, S. (2014). Factors contributing to non-value adding activities in South African construction. *Journal of Engineering, Design and Technology*,12 (2), 223 – 243.

Federal Republic of Nigeria. National Bureau of Statistics (NBS). (2015). *Nigeria Construction Sector Summary Report 2010-2012*. Abuja, Nigeria: National Bureau of Statisitics.

Federal Republic of Nigeria. National Bureau of Statistics (NBS) (2016). *Nigeria Gross Domestic Product Quarter One 2016*. Abuja, Nigeria: National Bureau of Statistics.

Fernandez-Solis, J.L., Porwal, V., Lavy, S., Shafaat, A., Rybkowski, Z.K., Son, K. and Lagoo, N. (2012). Survey of motivations, benefits, and implementation challenges of Last Planner System users. *Journal of Construction Engineering and Management*, 139(4), 354-360.

Flores, F. (1982). *Management and communication in the office of the future.* A dissertation submitted to the University of California , Berkeleyfor the award of a doctoral degree.

Fuemana, J. and Puolitaival, T. (2013). Last Planner System – a step towards improving the productivity of New Zealand construction. *Proceedings of the 21th Annual Conference of the International Group for Lean Construction*. Fortaleza, Brazil. 31 July-2 August . pp. 679-688.

Hamzeh, F. and Bergstrom, E. (2010). The lean transformation: A framework for successful implementation of the Last Planner System in construction. *Proceedings of the 46th Annual International Conference of the Associated Schools of Construction*. Wentworth Institute of Technology, Boston, MA. 7 – 10 April.

Hayek, F.A. (1945). The use of knowledge in society. *The American Economic Review*, 519-530.

Henn, M., Weinstein, M. and Foard, N. (2005). *A short introduction to social research.* London: Sage.

Howell, G. and Ballard, G. (1998). Implementing lean construction: Understanding and action. *Proceedings of the 6th Annual Conference of the International Group for Lean Construction*. Guaraja, Brazil. 13 – 15 August.

Johansen, E. and Walter, L. (2007). Lean construction — Prospects for the German construction industry. *Lean Construction Journal*, 3(1), 19–32.

JØrgensen, B., Emmitt, S. and Bonke, S. (2004). Integrating design and construction: Basic coordination issues. *Proceedings of the CIB World Building Congress*, Salford, U.K.

Khanh, H. D. and Kim, S. Y. (2014). Practitioners' perception on relationship between production planning and waste occurrence in construction projects. *KICEM Journal of Construction Engineering and Project Management*, 4(3),1-12.

Koskela, L. (1999). Management of production in construction: A theoretical view. *Proceedings of the 7th Annual Conference for the International Group for Lean Construction*, Berkeley, USA. pp. 241- 252.

Koskela, L. (1992). Application of the new production philosophy to construction. *Technical Report No. 72, Centre for Integrated Facility Engineering, Department of Civil Engineering*. Stanford University: Stanford, CA.

Koskela, L. (2000). *An exploration towards a production theory and its application to construction.* A dissertation submitted to the VTT Technical Research Centre of Finland for the award of a doctoral degree.

Koskela, L. (2008). Which kind of science is construction management? *Proceedings of the 16th International Group for Lean Construction (IGLC Conference)*. Manchester, UK. 16 – 18 July.

Koskela, L., Stratton, R. and Koskenvesa, A. (2010). Last Planner and critical chain in construction management: Comparative analysis. In: K.Walshand T. Alves, T. (eds.). *Proceedings of the 18th Annual Conference of the International Group for Lean Construction.* Haifa, Israel. 14-16 July. pp. 538-547.

Lean Construction Institute (LCI). (2016). *The Last Planner*. Available at: http://www.leanconstruction.org/training/the-last-planner

Lim, C. W., Yu, J. H. and Kim, C. D. (2006). Implementing PPC in Korea's construction industry. *Proceedings of the 14th Annual Conference of the International Group for Lean Construction*. Santiago, Chile. 25 – 27 July. .

Liu, M. and Ballard, G. (2008). Improving labour productivity through production control. In: :P. Tzortzopoulos and M. Kagioglou (Eds.). *Proceedings of the 16th Annual Conference of the International Group for Lean Construction*, Manchester, UK. 16-18 July. pp. 657-666.

Morledge, R., Smith, A. and Kashiwagi, D. T. (2006). *Building procurement*. Oxford: Blackwell Publishing.

Mossman, A. (2014). *Last Planner: Collaborative conversations for predictable design and construction*. Available at: http://www.academia.edu/1267793/Last_Planner_collaborative_conversations_for_predictable_design_and_construction_delivery.

Ojo, S.O., Adeyemi, A.Y. and Fagbenle, O.I. (2006). The performance of traditional contract procurement on housing projects in Nigeria. *Civil Engineering Dimension*, 6(2), 81-86.

Oladiran, O.J. (2009). Innovative waste management through the use of waste management plans on construction projects in Nigeria. *Architectural Engineering and Design Management*, 5(3), 165-176.

Olusegun, A. E. Benson, O.A., Esther, A.I. and Michael, A. O. (2011). Corruption in the construction industry of Nigeria: Causes and solutions. *Journal of Emerging Trends in Economics and Management Sciences*, 2(3).

Oluwakiyesi, T. (2011). Construction industry report: Haven of opportunities.Available at: http://www.proshareng.com/admin/upload/reports/VetivResearchConstructioSectorReportMay2011.pdf

Oyewobi, L.O. and Ogunsemi, D.R. (2010). Factors influencing reworks occurrence in construction: A study of selected building projects in Nigeria. *Journal of Building Performance*, 1(1), 1-20.

Oyewobi, L. O., Oke, A. A., Ganiyu, B. O., Shittu, A. A., Isa, R. B. and Nwokobia, L. (2011). The effect of project types on the occurrence of rework in expanding

economy. *Journal of Civil Engineering and Construction Technology* 2(6), 119-124.

Pasquire, C.L. and Connolly, G.E. (2002) Leaner construction through off-site manufacturing. In: C.T. Formoso and G. Ballard (eds.). *Proceedings of the 10th Annual Conference of the International Group for Lean Construction.* Gramado, Brazil. 6-8 August. pp.163-176.

Ralph, A. O. and Iyagba, R. (2012). Factors affecting contractor performance: A comparative study of non value-adding activities in Nigeria and Indonesia. *Journal of Emerging Trends in Economics and Management Science,* 3(5).

Ramos, S. (2014). Hiring and retaining the right people. *Construction Executive.* Available at: https://enewsletters.constructionexec.com/managingyourbusiness/2014/12/hiring-and-retaining-the-right-people/

Salem, O., Solomon, J., Genaidy, A. and Minkarah, I. (2006). Lean construction: From theory to implementation. *Journal of Management in Engineering*, 22(4).

Stifi, A., Gehbauer, F. and Gentes, S. (2014).The picture of integrity from lean management's point of view and the relationship between integrity management system and Last Planner System. In: B.T. Kalsaas, L. Koskela and T.A. Saurin (eds.). *Proceedings of 22nd Annual Conference of the International Group for Lean Construction*. Oslo, Norway. 25-27 June. pp. 907-918.

Thomas, H.R., Horman, M.J., De Souza, U.E.L.and Zavrski, I. (2002). Reducing variability to improve performance as a lean construction principle. *Journal of Construction Engineering and management*, 128 (2).

Zhao, Y.and Chua, D.K. (2003). Relationship between productivity and non-value adding activities. *Proceedings of the 11th Annual Conference of the International Group for Lean Construction*. Blacksburg, USA .

A GEMBA KAIZEN MODEL BASED ON BPMN FOR SMALL- AND MEDIUM-SCALE CONSTRUCTION BUSINESSES IN NIGERIA

Temitope OMOTAYO[1] and Udayangani KULATUNGA[2]

[1]Scott Sutherland School of Architecture and the Built Environment, Robert Gordon University, Aberdeen, United Kingdom, AB10 7GJ, Tel.:+44 01224263720, Email: t.s.omotayo@rgu.ac.uk
[2]School of the Built Environment, University of Salford, Manchester, United Kingdom, M5 4WT, Tel.:+44 01612956943, Email: u.kulatunga@salford.ac.uk

ABSTRACT

This article presents a demonstration of how gemba kaizen, which is continuous improvement in the workplace, can be implemented using business process modelling and notation (BPMN). The scope of the study is construction businesses in Nigeria. In developing the BPMN model for construction businesses in Nigeria, the modus operandi regarding decision making and managing challenges which may be transferred to the cost planning was identified. The mixed-method approach was used to develop this model from the qualitative and quantitative findings. The survey strategy was employed for the analysis, covering eleven interviews and one hundred and thirty-five questionnaires from contractorsand cost and project managers in small- and medium-scale companies in Lagos, Nigeria. NVIVO 10 and descriptive statistics were used to assess the results. The findings of the study focused on the perception towards change, post-project reviews, openness to new ideas, and innovation. The study observed post-project reviews as the only significant indicator of continuous improvement in Nigerian small- and medium-scale construction companies. This result is not enough to indicate that there is continuous improvement. Therefore, the model design focused on continuous improvement activities for the companies. The creation of a BPM model elucidated the continuous improvement functions, stages and processes. This study may be implemented in construction companies in developing economies for improving the competitive advantage of small- and medium-scale construction companies.

Keywords: construction companies; gemba; kaizen; small- and medium-scale; workplace

INTRODUCTION

Small- and medium-scale enterprises (SMEs) are the drivers of any economy (Holatova and Brezinova, 2013). Between the years 2014 and 2015, the United Kingdom (UK) government spent over £4.5 billion on SMEs (The Comptroller and Auditor General, 2016). This spending is part of the UK government's decision to improve the growth of the economy. Furthermore, small business accounted for 99.3% of privately owned businesses in the UK. The UK government has also increased its spending on SMEs after 2015 (Woods and Dennis, 2009; The Comptroller and Auditor General, 2016). Governments' spending on SMEs varies, based on the country and economy. The construction industry is part of the SMEs, and the business processes are unique. Allocation of funds for SMEs by the government has not always translated to improvement in these companies (The Comptroller and Auditor General, 2016; Simpson et al., 2006; Rostami et al., 2015; Kuivalainen et al., 2012). These companies have challenges related to management functions within the organisation, business development and strategy, risk identification and mitigation, and improving the competitive advantage (Simpson et al., 2006; Rostami et al., 2015; Binks et al., 1990).

There are SME construction companies in the UK construction industry faced with the problem of improving their competitive advantage. Construction companies are businesses, and they have the sole aim of making a profit in a competitive industry. This is also the same for the construction sector. Small- and medium-scale construction businesses (SMSCBs) around the world face many challenges. These problems have limited their competitiveness in the construction sector. There are various peculiarities in the construction sector which retard the growth of SMSCBs; these are related to the type of economy and government regulations. Staff strength is used for determining SMSCB in the UK. In Nigeria, a team strength below 50 is considered small, while figures above 50 are medium scale. The amount of fund and annual turnover also decides whether the company will be small or medium scale. Different countries having individual metrics for judging the size of a company makes it difficult to address the organisational culture and improvement processes in these enterprises.

Eniola (2014) as cited by Eniola et al. (2015) noted that there is no accurate definition for small- and medium-scale enterprises (SMEs). This is because the parameters, which include the size of the fixed assets, personnel, technology, production, output, system or management or capital, are subjective, according to various analysts. Therefore, the definition of small- and medium-scale enterprises depends on the economic judgement of the country in which the company is situated. Eniola et al. (2015) further noted that the Central Bank of Nigeria (CBN) defines an SME as a company with fewer than 50 and 100 staff for small- and medium-scale enterprises respectively.

The asset criterion is between one (1) million naira (£3,293.98) and one hundred

and fifty (150) million naira (£494,096.92) for small- and medium-scale enterprises respectively. These values are used in this study to categorise small- and medium-scale construction companies.

The competitive advantage of an SMSCB depends on funding, management, and organisational culture. Funding may be a major problem with SMSCBs, but other factors have to be taken into consideration as well. These are corporate culture and waste management policies.

ORGANISATIONAL CULTURE OF SMSCB

The concept of organisational culture has been a primary focus in this research study conducted in the built environment and other management disciplines. Organisational culture describes the opinions of the owners of the company, and it binds the stakeholders within the company together (Issa and Haddad, 2008). Organisational culture is a collection of internal and external factors that lead to the establishment of beliefs, customs morals, knowledge and policies. Therefore, the formation of culture within an organisation depends on several factors, and it is a process leading to the formation of policies. These factors are peculiar to the nature of the environment in which the company is situated, government policies, the nature of the economy, the makeup of the company (the type of company), and other internal influences (Alashwal and Abdul-Rahman, 2014; Ribeiro, 2009; Norma et al., 2010; Kransdorff, 1996). This is also related to the main purpose of improving the organisation for competitiveness and growth.

There are aspects of organisational culture that are very visible based on the behaviour of the organisation. Some organisations have behaviours that are latent (Issa and Haddad, 2008; Anumba et al., 2008; Anumba et al., 2002). Therefore, there is a need to investigate the behaviour of organisations regarding a perspective. This point of view may relate to the style of communication in the workplace or response to change. In examining communication in organisations, there are various approaches. There is nonverbal communication, meetings, memos, a top-down approach and a bottom-up approach, among others (Hoogervorst et al., 2004; Larson and Kleiner, 2004; Dawson-Shepherd, 1997). Furthermore, communication within organisations may be regarded as implicit or explicit communication. Implicit interfaces aim to transfer knowledge to the employees, while specific behaviours may intentionally move information to change the conduct of the employees (Hoogervorst et al., 2004). This may be about the quality of communication and ways of improving it.

In the case of continuous improvement, the purpose is explicit, and it has to be able to transfer information to change the attitude of the employees. If employees are performing well, the organisation will perform well. This fact is well-known for organisational culture. Organisations structure buildings on the organisational culture. The organisational structure depends on the type of country, and the types of

communication in these structures vary.

Organisational culture also develops into corporate learning. However, this is only when the organisation decides to make use of what they have learned over the years. This may be carried out via a post-project review. A post-project review is a form of organisation learning whereby the organisation decides to improve the present conditions. In the construction industry, some of the valuable lessons which should have been learnt during the project are compiled as a form of knowledge management for future use (Kululanga and Kuotcha, 2008; Singhvi, 1986). Post-project reviews lead to the improvement of organisations if they are executed and evaluated for further reviews.

The challenge with the construction industry in Nigeria and SMSCCs in the country is business ethics. Business ethics here are characterised by corruption and the quality of cost information, or, in other words, a lack of professionalism.

Making a case for gemba kaizen in Nigerian SMSCB

Issa (2013) noted that waste, which is referred to as *muda* in Japanese, might be in the form of duration, production, transportation, stock at hand, processing, movement, and producing faulty products. The concept of waste in lean construction may be viewed from the perspective of Al-Aomar (2012), and Issa (2013) who define it according to the overall activities of the organization, which involve the production aspect.

Gemba kaizen is related to kaizen in the workplace (Imai, 1997; Chukwubuikem et al., 2013; Singh and Singh, 2012; Isa, 2013). This concept may be viewed in the simplest term as reducing any form of waste within the office. It is a product of the lean production principles. Waste management practices in kaizen costing areviewed from the perspective of production residues. However, the overall concept of kaizen also perceives waste from the administrative aspect. The idea of kaizen which is a continuous improvement during production is one of the derivatives of lean production.

Singh and Singh (2012) reviewed the history, evolution, and the concept of continuous improvement in organisations over the years. The findings show that continuous improvement, otherwise known as kaizen, has been used to improve an organisation's performance over the decades. Kaizen focuses more on reducing waste before and during construction. The concept of kaizen costing is a method used in reducing waste during construction (Chukwubuikem et al., 2013). This approach has been used principally in the manufacturing industry in many countries around the world. The concept is relatively new in the construction sector.The managerial situation of most small- and medium-scale construction firms may be an indication of the unavailability of gemba kaizen for waste reduction in the workplace.

The management function of waste reduction depends on the existing policies. If there is no current policy on waste reduction, then it will take several months or

years for the organisation to attain this stage. This is a research gap in this investigation. Building up a continuous improvement process within the existing organisational structure of SMSCB depends on various indicators. These indicators are the potential presence of kaizen, the perception towards change, waste management policies, and post-project reviews for organisational learning. Communication within the organisation as discussed in section 2.0 drives the overall process of continuous improvement of the SMSCB in Nigeria.

These indicators lead to the method of data collection, analysis, and business model development to enhance the existing process.

The aim of this study was to analyse the extent to which gemba kaizen can be adopted for construction business using business process modelling and notation (BPMN). Therefore in the next section, the research methodology and analysis are discussed and a BPMN model is designed.

RESEARCH METHODOLOGY

The survey strategy was adopted for this study because it covers a broader population compared to other research strategies. De Vaus (2002) stated that a survey approach is used to obtain data for a large population with the aid of techniques such as questionnaires and in-depth interviews. According to Sapsford and Jupp (2006), a survey is meticulous and can be quantified. It also gives details about a population. Surveys target a larger population compared to focus groups and case studies. Therefore, the survey covered the areas of quantitative and qualitative data collection. The first phase of this investigation covered survey interviews. Survey questions were used to gather data from small- and medium-scale construction companies in Lagos, Nigeria.

The survey questions were designed in a semi-structured manner based on literature related to kaizen in the workplace. The literature review process informed the questions used for the interviews. The questions were based on the central tenets of continuous improvement in the workplace: this deals with process improvement, waste reduction policy, financial and time management, organisational policies, the mission statement and post-project reviews. These areas are related to the concept of gemba kaizen. The details of what gemba kaizen means were included in the participant information sheet for the interviewees. The data collection involved eleven (11) highly qualified project and cost managers in eight (8) small- and medium-scale construction businesses. This sampling technique is purposive sampling, targeting the right population with the necessary experience (Saunders et al., 2012). The interviewees have between 15 to 29 years of experience in the construction industry. The respondents also have qualifications ranging from BSc degrees to MSc degrees in quantity surveying and construction or project management. The interviewees' backgrounds are summarised in the table below.

Table 1: Interviewees'demographic details

Profession	Code	Job role	Years of experience	Highest qualification	Project type
Quantity surveyor	CM1	Managing Director	15	MSc	Building and civil engineering
Project manager/ Architect	PM1	Managing Director	20	BSc	Building and civil engineering construction
Project manager/ Architect	PM2	General Manager	21	BSc	Building construction
Project manager	PM3	Managing Director	15	MSc	Building and airport construction
Quantity surveyor	CM2	Principal partner	17	BSc	Building construction
Project manager	PM4	Contractor/Director	25	BSc	Residential housing
Quantity surveyor	CM3	Principal partner	23	BSc	Building construction
Quantity surveyor	CM4	Chairman	29	BSc	Building construction
Project manager	PM5	General manager	19	MSc	Building and residential housing
Quantity surveyor	CM5	Assistant Director	17	MSc	Building and civil engineering
Quantity surveyor	CM6	Director	23	BSc	Building and civil engineering

(Source: Authors)

A theoretical sampling approach was adopted for the semi-structured interviews. The years of experience for each of the respondents are paramount. Theoretical sampling enables the researcher to obtain the required knowledge from the experts. This does not depend on the random larger population but on a few experts with in-depth knowledge of the subject. Fifteen years of experience in the construction industry is the least amount of experience , and the combined experience for all the

respondents is 224 years. The unit of analysis of this study is business operations.

The respondents in Table 1 are top executives and principal partners in construction and quantity surveying firms. Some of quantity surveying firms in Nigeria work alongside the contractors. Therefore, the primary partners have been interviewed as part of this study. Quantitative data were obtained from 135 respondents. The findings were triangulated with the interview responses. The development of the model from the qualitative and quantitative data analysis made use of the business process model and notation. This model is explained in the next section.

Business process model and notation (BPMN)

The business process model and notation (BPMN) utilises standard business process diagrams (BPDs) to represent the processes involved in business. The BPMN was developed by an industry association known as BPMN. Org (Recker, 2010). This group is only a collection of annotations without an end-user. (Johannsen et al., 2014, Recker, 2010). BPMN is used for improving business processes (Johannsen et al., 2014). The process diagrams are represented as graphical notations similar to the function flowchart procedure. BPMN identifies not only the processes involved in the business but also the stakeholders. BPMN is a modelling tool available on Microsoft Vision: although there is specialised software for BPMN, the core concept of modelling the business process is the same. It provides execution languages and graphics for business administrators. This modelling technique used by business developers can also be applied to SMSCBs in Nigeria. The first step is to address the interview findings and analyse the themes.

Interview findings

The semi-structured interviews were conducted via telephone. The conversations were recorded directly on a voice recording application installed on the phone. After transcribing the interviews, seven (7) themes were identified using the NVIVO 10 software. These themes are highlighted below.

Mission statement and core values

According to interviewee CM5, the mission statement and core values of their organisation are:

> "*…to perform our services to the highest level of professionalism and the satisfaction of our clients. Our core values are honesty and integrity, teamwork, innovation and commitment to safe operation and sound ethics…"* (Transcribed interview, 2015).

The key words here are 'professionalism', 'honesty', 'integrity', 'teamwork', 'innovation' and 'client satisfaction'. Nevertheless, some respondents had different mission statements and core values which are not related to innovation, teamwork or

professionalism. An example of this is respondent PM3 who stated that:

> "*…to become the leading Engineering and Construction firm in Nigeria and Africa, while delivering projects that consistently meet international standards..."* (Transcribed, interview, 2015).

Respondent PM3's organisation is aimed at becoming a top engineering and construction organisation in Nigeria and Africa. There was no indication of innovation and improvement of the company, client satisfaction, or teamwork. This may not indicate the present status of small- and medium-scale organisations because only two respondents gave this type of response. This may depend on the complexity or the organisational structure as well as other factors. Three (3) respondents mentioned innovation and teamwork, while six (6) respondents referred to the quality of service. These keywords or sub-themes are related to kaizen.

Organisational structure complexity

The organisational structure was distinguished as simple or complex. All eleven respondents categorised their organisational structure as simple. From a director CM6 of a small- and medium-scale construction company in Lagos:

> "*…It depends on the communication between the staff and the temporary staff, but our structure is simple..."* (Transcribed interview, 2015).

Owing to the small number of personnel of some of the construction companies, some of these organisations do not have supervisors. The staff report directly to the owner of the enterprise. However, in medium-scale construction organisations there is a supervisor in the hierarchy between the owner (prime contractor) and other employees.

Communication approach

The style of communication may be very useful in identifying the presence of kaizen in small- and medium-scale construction firms in Nigeria. Shang and Pheng (2013) state that effective communication is essential for kaizen; in this case, gemba kaizen. The communication approach may be top-down or bottom-up or non-specific. Eleven respondents noted that the top-down approach is the primary communication approach in their organisations. According to respondent CM4 who is a chairman of the company:

> *"…communication within our company is very easy and fluid, but at times it depends on the communication between the staff and the temporary staff, but our structure is simple…"* (Transcribed interview, 2015).

In this response, the respondent CM4 also indicated that communication between the staff and other employees who are temporary workers in the office and on the site is essential although the management of the company may be involved in daily communication via memos as indicated by respondent CM1:

"*…We send out notes and organise meetings with the staff. There is no particular pattern of communication..."* (Transcribed transcript, 2015).

Regular meetings in the office and memos are a means of communication. Respondent CM1 indicated that there is no particular approach within his organisation. In this instance, it may not be adequate to identify and eliminate specific problemswithin the organisation. Waste elimination will be difficult if there is poor communication between workers and management. Four (4) respondents who are employees in an organisation noted that memos are sent to staff on a regular basis. Three interviewees pointed out that new ideas could easily be communicated within the organisation. Kaizen may thrive latently within an organisation that embraces innovation and openness to new ideas.

Waste reduction policy

Waste reduction is an evidence of continuous improvement. Singh and Singh (2015) and Smadi (2009) identified waste reduction as an essential element of gemba kaizen for improving competitiveness in the workplace. Therefore, having a waste reduction policy is related to gemba kaizen. Respondent PM2 noted that:

"…there is no policy on time management, but we have a documented plan on material waste reduction." (Transcribed interview, 2015).

All the three (3) respondents review their companies' waste reduction policies regularly. The concept of a waste decrease in an establishment is an element of kaizen. This is related to the employee-employer relationship. In investigating the presence of kaizen within small- and medium-scale construction firms in Nigeria, identifying waste reduction policies is an indication of how the management function addresses continuous improvement. Reviewing existing policies on waste reduction provides a clearer understanding of how the system behaves towards cost reduction. In total eight (8) directorsinterviewed do not have any documented policy on reducing waste in their firms.

Heard about kaizen or continuous improvement

For instance, respondent, CM2 noted that:

"*…I have not heard of kaizen, but I have listened of [sic] continuous improvement in a conference*." (Transcribed interview, 2015).

The terminology *kaizen* is Japanese, and this term may not be used by the management consultants who train various employees in Nigeria. Therefore, 'continuous improvement' is a more familiar word compared to 'kaizen' in Nigeria. The idea of kaizen is also related to manufacturing and not construction. This is indicated in the comments of respondent PM1:

"...I have heard about kaizen, but it is only used in production…" (Transcribed interview, 2015).

Implementing kaizen in small- and medium-scale construction organisations

in Lagos, Nigeria may face a challenge because of the understanding that it is used in the manufacturing sector (Please refer to section 2.6.3). However, some manufacturing principles are now used in construction. Some of these are off-site construction, lean construction, and modular buildings.

New to kaizen or continuous improvement

Respondent CM3 noted that:

> "…*From my knowledge continuous improvement is broad, and it can be used in any area. It is related to waste reduction and time management, in fact, it is used to reduce non-productive activities." (*Transcribed interview, 2015).

From the findings, only one respondent provided detailed information relating to what he knows about kaizen or continuous improvement. Although this interviewee's understanding of kaizen has to do with waste reduction and time management, it may also be applied to construction activities. The use of kaizen during construction has been investigated in the quantitative data collection (questionnaires). The finding was triangulated with openness to new ideas and innovation.

Post-project reviews

Post-project reviews are meetings and studies carried out after the completion of any project. Post-project reviews also involve key performance indicators for performance and productivity measurement after a project (Holt and Graves, 2001,;Yang et al., 2010). Hence, continuous improvement may be achieved in the workplace. Respondent PM3 agreed that:

> *"…Yes, we do organise after-project meetings to analyse our performance, and we have been improving on it."* (Transcribed interview, 2015).

The transcribed interview of respondent PM3 highlights the fact that the performance of the company has been improving over the years based on post-project reviews. Other respondents such as CM2 also stated that:

> *"…post-project reviews have a positive impact on our projects, and it [sic]gives us the opportunity to identify our mistakes and improve our project delivery."* (Transcribed interview, 2015).

The post-project review is evidence of continuous improvement within a construction organisation. This aspect creates a channel to implement the tenets of gemba kaizen within a construction establishment.

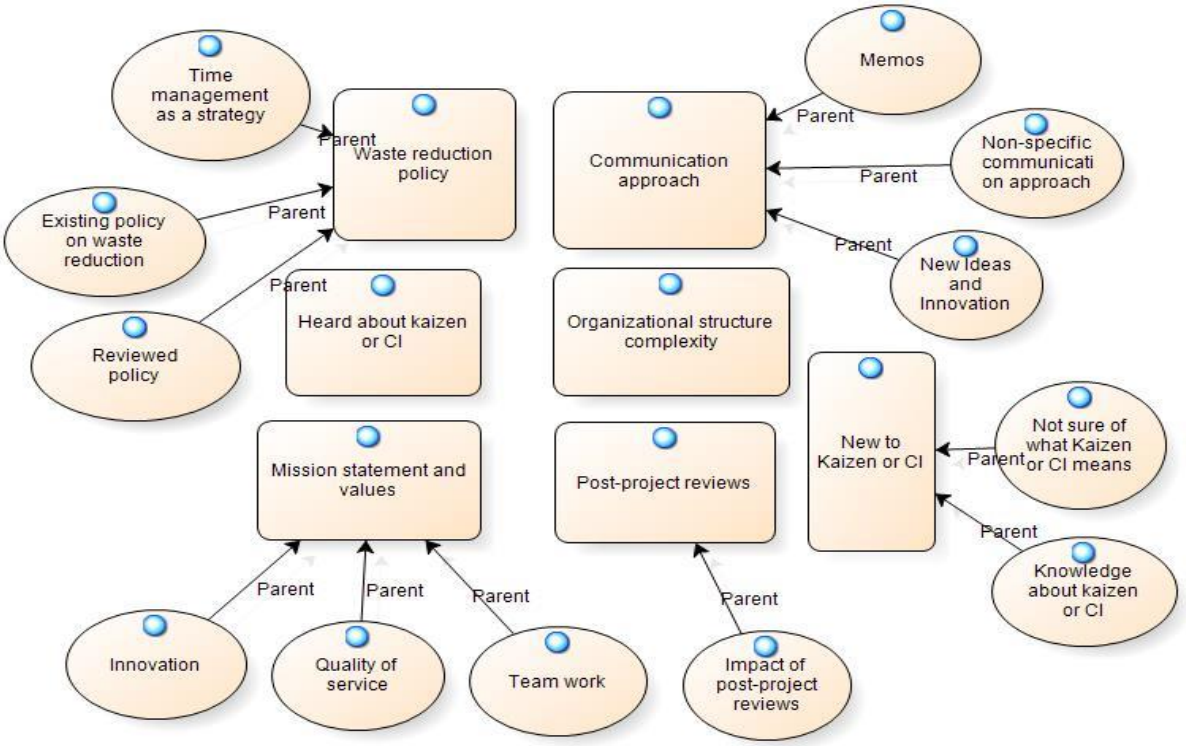

Figure 1: Model for the themes (Source: Authors)

In Figure 4, the organisational structure complexity in small- and medium-scale construction organisations can be seen to play a significant role in determining communication, waste reduction policy, mission statement and other themes. This is why it is sited in the middle of the model. Having identified the qualitative themes for gemba kaizen from the interviews, the quantitative aspect involves the category of the organisation and also the openness of these firms to continuous improvement in the workplace.

Quantitative data collection and analysis

Cost and project managers in small- and medium-scale construction companies in Nigeria were involved in the data collection process. Based on the literature review findings, 250 questionnaires were distributed to 84 small- and medium-scale construction firms in Nigeria. However, only 135 questionnaires were returned.

The questionnaire included details of what gemba kaizen is and how it may improve their organisation. This was introduced to the participants as continuous improvement in the workplace. Sixty-six point seven per cent (66.7%) of the respondents have a staff strength below 50. Therefore, the majority of the respondents to the questionnaire are involved in small-scale construction organisations.

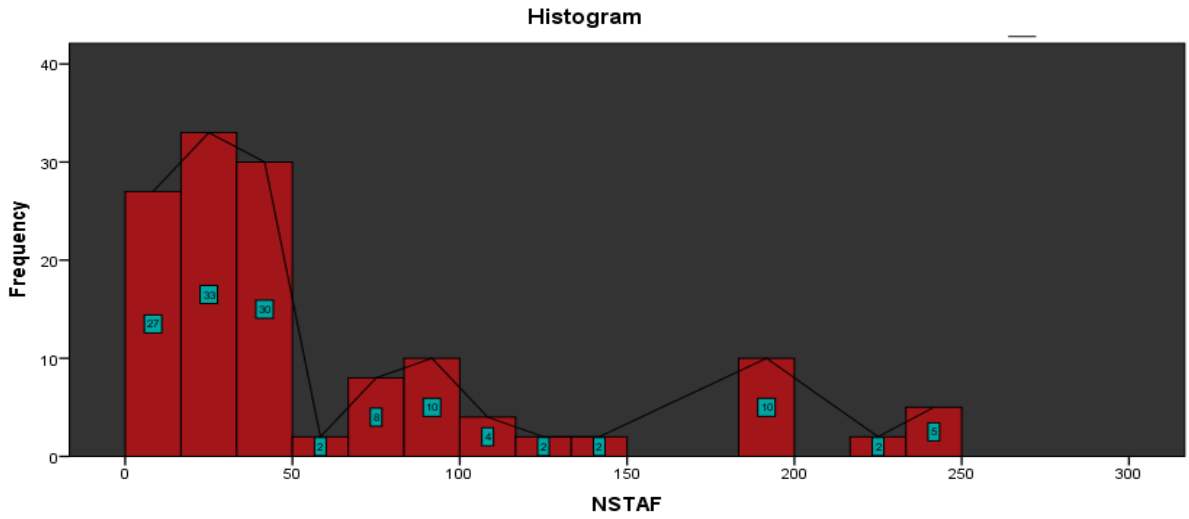

Figure 2: Distribution of numbers of staff

The frequency distribution of the size of the respondents' firms also reveals the total number between zero (0) and fifty (50) staff in the businesses as the highest number of respondents.

Openness of the construction firms to gemba kaizen as a new idea

The openness to gemba kaizen as new ideas and innovation such as kaizen was the focus of the survey. Openness to the new idea within these organisations was investigated. The responses are based on the perspective of the employees rather than management. This provided more suitable answers compared to those of management, because in many instances, the organisation may want to protect itself by offering positive responses. Nonetheless, it was gathered that nine (9) organisations out of the 135 responses were not open to new ideas or innovation from the employees. Sixty-five (65) respondents noted that their company was slightly open to new ideas. This implies that not all ideas are welcome and the respondents find it difficult to communicate suggestions to upper management. Forty-six (46) respondents highlighted that their organisations are open to new ideas whenever they are presented to them. In this instance, the employees (respondents) find it very easy to communicate their suggestions and ideas to upper management and management acts on these to improve.

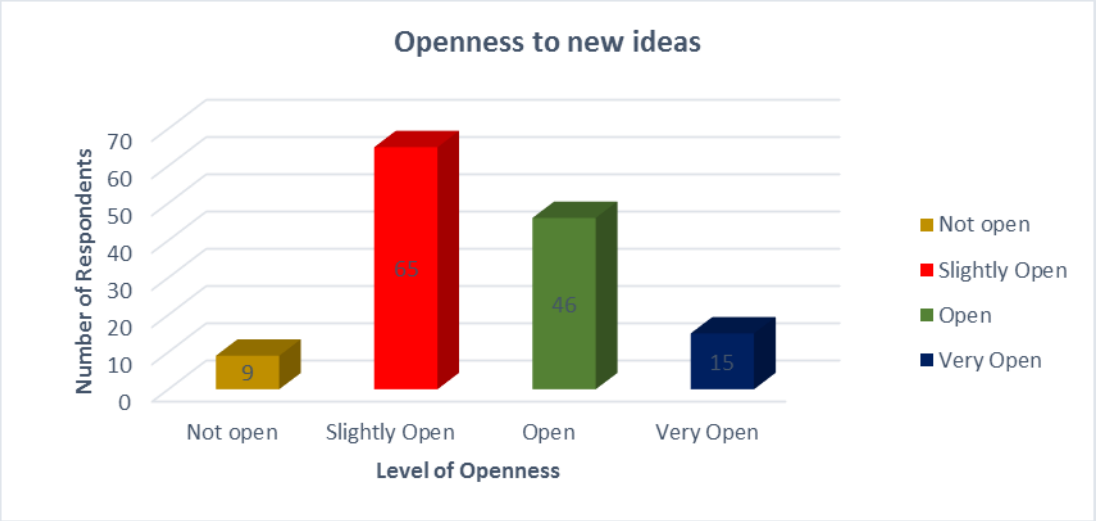

Figure 3: Level of openness to gemba kaizen as a new idea

The "very open" category was answered by only 15 respondents. This group of respondents indicated that their organisations made excellent use of their ideas to improve and innovate quickly. In such organisations, the management may have research teams. From the findings, very few small- and medium-scale construction organisations respond to new ideas, while the larger population of the respondents believe that their organisations are slightly open to new ideas and innovation.

DISCUSSION

The triangulation process for the findings ensures content validity and corroborates the qualitative findings with the quantitative. Although it would be difficult to identify the presence of kaizen accurately in small- and medium-scale construction organisations in Lagos, Nigeria, the method of data collection and analysis provided much information about the nature of these organisations. Eleven (11) top executives from small- and medium- scale construction firms in Lagos were interviewed, and 135 questionnaires were retrieved. The semi-structured interviews which were transcribed were analysed using NVIVO 10. Nine themes were identified, namely staff; mission statement and core values; organisation structure complexity; communication approach; waste reduction policy; heard about kaizen or continuous improvement; new to kaizen or continuous improvement; post-contract cost control process; and post-project reviews. These nine themes were analysed along with the various sub-themes.

The mission statement and core values themes pertain to what the organisation stands for. Although most times these are merely words spelt out on paper, they show the orientation of the business. 'Integrity', 'innovation', 'teamwork', 'client satisfaction', and 'good business ethics' are some of the keywords from the mission

statement and core values themes. Small- and medium-scale businesses strive to be innovative in their activities, but this may not be possible with the present competitive level of small- and medium-scale construction firms in Nigeria. The number and type of staff employed by these companies reflect their mode of operation for continuous improvement and innovation. Unskilled or ad hoc staff may not be able to advise the management in certain areas compared to skilled staff. Therefore, there may be a low level of continuous improvement in such a workplace.

The organisational structure in small- and medium-scale construction firms in Nigeria shows that firms with a simple structure have very few staff. Thus it is easier to implement new ideas within the organisation. The communication approach within these organisations is top-down in nature, with communication tools such as memos and regular office meetings being dominant. Only three (3) respondents had a waste reduction policy within their company, and the companies of five (5) interviewees had a policy on time management. Waste reduction strategy in business may be evidence of latent kaizen. Notwithstanding, these policies are not sufficiently robust to cover the requirement for continuous improvement in the workplace.

The major challenge is the level of knowledge of kaizen within these companies. Therefore, the interviewees were asked whether they had heard about kaizen or continuous improvement. Based on the responses , it seems that kaizen was a new term to the respondents. Continuous improvement within small- and medium-scale construction businesses in Lagos, Nigeria was non-existent. Nonetheless, the general view of respondents in these construction companies was explored with the aid of the questionnaire. The questions asked were based on openness to new ideas and innovations. The findings revealed that 48% of the respondents believe that their organisations were slightly open to new ideas and innovation, while 34% of the interviewees indicated otherwise. Eleven per cent (11%) responded that their organisations were very open and just seven per cent of the respondents thought their organisations were not open. The overall findings of the questionnaire show that most small- and medium-scale construction firms are not very open to new ideas or innovation. If these companies are not open to new idea and changes such as gemba kaizen, then this indicates that the majority of the companies have little or no evidence of continuous improvement.

The post-project review is evidence of kaizen in business. This practice was identified in seven (7) small- and medium-scale businesses during the interviews process . Post-project reviews have had a positive impact on these firms. In a situation where the director of a construction company is familiar with post-project reviews, introducing continuous improvement to them would be easy compared to the remaining four (4) businesses that stated that they did not use post- project reviews.

From the findings, most employees of these construction firms thought that their

business would be slightly open to new ideas and innovation such as kaizen. This is based on their perception of their existing relationship with the top management. Even though some respondents practised *muda* elimination and had mission statements related to gemba kaizen, the activities of entrepreneurs of small- and medium-scale construction firms in Lagos, Nigeria did not pertain to what is expected of gemba kaizen.

Waste management in various construction industries has defined policies. In the UK the waste management policy is well implemented. The UK generates about 90 million tonnes of construction waste annually (Williams and Turner, 2010). It was further noted that waste produced comes from packaging; leftovers from building materials; design error or changes; poor storage; pilfering and handling of materials. These sources depend on the nature of the construction industry. In developing construction industries such as that of Nigeria, the general causes of construction waste on site include poor allocation of resources; poor recording keeping; vandalism; variation and rework; damage as a result of weather or mishandling; damage as a result of transportation; composite and design of building; material supplied and used on site; and site office waste (Wahab and Lawal, 2011). The materials which generate waste on a site may be concrete, wood, metals, plastic, tiles, insulation, paints, soil and stones, ceramics, glass, and bricks. Waste generation on a site may be avoided, but the effects may lead to cost and time overruns. In some cases, it may put an abrupt end to the project. The concept of kaizen costing in construction waste reduction for improved profitability, sustainable construction, enhanced value and client satisfaction through better quality depends on factors other than waste reduction.

Waste management practices in kaizen costing are viewed from the perspective of production residues. However, the overall concept of kaizen also perceives waste from the administrative aspect. The idea of kaizen which is a continuous improvement during production is one of the derivatives of lean production. Singh and Singh (2012) reviewed the history, evolution, and the concept of continuous improvement in organisations over the years. Their findings show that continuous improvement, otherwise known as kaizen, has been used to improve organisations' performance over the decades. Kaizen focuses more on reducing waste before and during construction. The concept of kaizen costing is a method used in reducing waste during construction (Chukwubuikem et al., 2013). This approach has been foremost in the manufacturing industry in many countries around the world: however, the concept is relatively new in the construction sector.

Post-project reviews which also include site meetings are carried out within seven (7) out of the eleven (11) construction firms. Also, the high level of openness of these respondents' companies to continuous improvement may be an indication of continuous improvement. Nonetheless, there is a need for further training in the area of gemba kaizen.

Developing the BPMN model

BPMN is used to improve the current state of the construction business and activities on the construction site. The BPMN process made use of the findings and discussions. In Figure 4, the functions boxes are management, supervisor or line manager and staff. The kaizen in the office (gemba kaizen) starts with identifying the problems that need improvement within the office. The management or any other employee may determine this issue. The identified problem may be stored in a file or computer system for record purposes, and delegated for resolution. This delegation may be sent as a memo or email within the office. A kaizen supervisor can tackle the problem by looking at the non-value added activities within the company. The decision-making process here will be to schedule activities for immediate review or have a brainstorming session with the employees in the next function. At this stage, more problems may be identified in the office for resolution. The problems may be some activities that take more time and have led to financial losses.

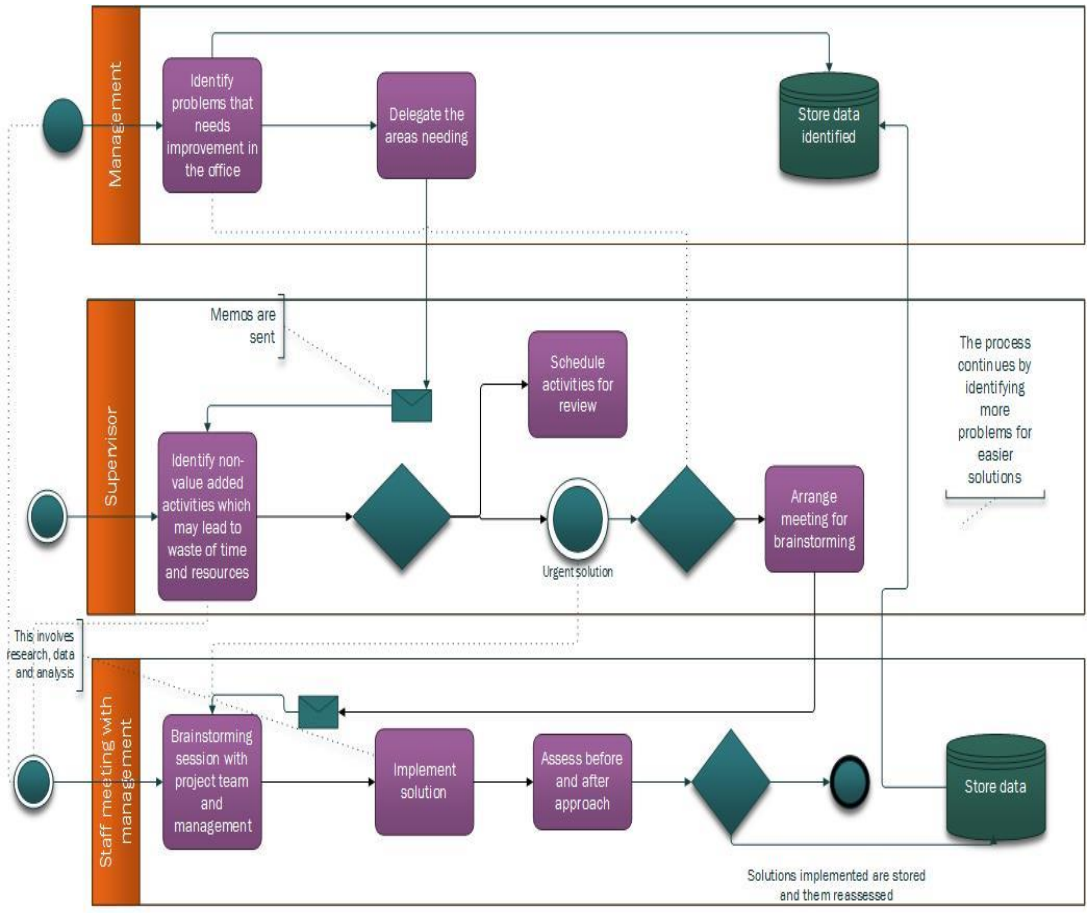

Figure 4: BPMN for kaizen process for a hypothetical SMSCB

Therefore, time management, resource allocation, financial management, and other waste-producing processes have to experience effective management. The management will need to be involved in this brainstorming meeting with the supervisors and other employees.

CONCLUSIONS

The presence of kaizen in SMSCCs in Nigeria is minimal, and there is a need for adequate training about the concept of continuous improvement in these SMSCBs before it can be implemented. The continuous improvement policies are similar to waste reduction policies mentioned earlier in the article. These SMSCBs have waste reduction policies, but they are not implemented or reviewed. The post-project review is a major indicator of kaizen in the workplace. Seven (7) interviewees out of eleven (11) noted that they conduct post-project review meetings. This an important basis for implementing kaizen and kaizen costing. Nonetheless, it is not enough to indicate that kaizen exists in SMSCBs. Waste reduction, innovation, and openness in SMSCBs proved that they have had to increase the involvement of stakeholders who are the construction professionals in waste reduction and maintenance of existing activities. In conclusion, the kaizen philosophy exists on a minimal level in Nigerian SMSCB.

The BPMN model developed in the article provides a simple approach for SMSCBs to enhance their operations within the construction industry. This will provide an opportunity for them to compete favourably with other smaller and medium-scale construction companies in Nigeria. Furthermore, this model may also be applied to SMSCBs in developing countries and beyond.

REFERENCES

Al-Aomar, R. (2012). A lean construction framework with six sigma rating. *International Journal of Lean Six Sigma,* 3**,** 299-314.

Alashwal, A.M. and Abdul-Rahman, H. (2014). Aspects of project learning in construction: A socio-technical model. *Construction Innovation*, 14(2), 229–244. doi.org/10.1108/CI-06-2013-0029.

Ameh, O.J. and Odusami, K.T. (2010). Professionals' ambivalence toward ethics in the Nigerian construction industry. *Journal of Professional Issues in Engineering Education & Practice,* 136**,** 9-16.

Anumba, C.J., Issa, R.R.A., Pan, J. and Mutis, I. (2008). Ontology-based information and knowledge management in construction. *Construction Innovation*, 8(3), 218–239.

Anumba, C.J., Baugh, C. and Khalfan, M.M.A. (2002). Organisational structures to support concurrent engineering in construction. *Industrial Management & Data Systems*, 102(5), 260–270.

Ayodele, E.O., Ogunbode, A.B., Ariyo, I.E. and Alabi, O.M. (2011). Corruption in the construction industry of Nigeria: Causes and solutions. *Journal of Emerging Trends in Economics and Management Sciences,* 2**,** 156-159.

British Broadcasting Corporation (BBC) (2002). *News.* Available at: http://news.bbc.co.uk/1/hi/business/2077838.stm.

Binks, M., Ennew, C. and Reed, G. (1990). The single market: Finance for small- and medium-sized enterprises. *International Journal of Bank Marketing*, 8(3), 24–28.

Chukwubuikem, P.V., Chinedu, E.F. and Mofolusho, M.O. (2013). Product cost management via the kaizen costing system: Perception of accountants. *Journal of Management and Sustainability,* 3**,** 114-125.

Dawson-Shepherd, A. (1997). Communication in organisations operating internationally. *Journal of Communication Management*, 2(2), 158–166.

De Vaus, D. (2002). *Research design in social research*. London: Sage Publications.

Eniola, A., Entebang, H. and Sakariyau, O.B. (2015). Small- and medium-scale business performance in Nigeria: Challenges faced from an intellectual capital perspective. *International Journal of Research Studies in Management,* 4**,** 59-71.

Hartmann, A. (2006). The role of organizational culture in motivating innovative behaviour in construction firms. *Construction Innovation*, 6(3), 159–172.

Holatova, D. and Brezinova, M. (2013). Basic characteristics of small- and medium-sized enterprises in terms of their strategic management. *International Journal of Business and Social Science*, 4(15), 31–34.

Hoogervorst, J., Van der Flier, H. and Koopman, P. (2004). Implicit communication in organisations: The impact of culture, structure and management practices on employee behaviour. *Journal of Managerial Psychology*, 19(3), 288–311.

Imai, M. (1997). Gemba kaizen: A commonsense, low-cost approach to management. New York: McGraw-Hill.

Isa, R.B., Jimoh, R.A. and Achuenu, E. (2013). An overview of the contribution of construction sector to sustainable development in Nigeria. *Net Journal of Business Management,* 1**,** 1-6.

Issa, R.R.A. and Haddad, J. (2008). Perceptions of the impacts of organizational culture and information technology on knowledge sharing in construction. *Construction Innovation*, 8(3), 182–201.

Kransdorff, A. (1996). Using the benefits of hindsight - the role of post-project analysis. *The Learning Organization*, 3(1), 11–15.

Kuivalainen, O., Sundqvist, S. Saarenketo, S. and McNaughton, R. (2012). Internationalization patterns of small- and medium-sized enterprises. *International Marketing Review*, 29(5), 448–465.

Kululanga, G.K. and Kuotcha, W.S. (2008). Measuring organisational learning through project reviews. *Engineering, Construction and Architectural*

Management, 15(6), 580–595.

Larson, J. and Kleiner, B.H. (2004). How to read non-verbal communication in organisations. *Management Research News*, 27(4/5), 17–22.

Ribeiro, F.L. (2009). Enhancing knowledge management in construction firms. *Construction Innovation*, 9(3), 268–284.

Rostami, A., Sommerville, J., Wong, I.L. and Lee, C. (2015). Risk management implementation in small and medium enterprises in the UK construction industry. *Engineering, Construction and Architectural Management*, 22(1), 91–107.

Saad, N., M., Majid, M.S.A., Kassim, S., Hamid, Z. and Yusof, R.M. (2010). A comparative analysis of the performance of conventional and Islamic unit trust companies in Malaysia. *International Journal of Managerial Finance*, 6(1), 24–47.

Sapsford, R. and Jupp, V. (2006). *Data collection and analysis* (2nd ed.). London: Sage Publications.

Saunders, M., Lewis, P. and Thornhill, A. (2015). *Research methods for business students* (7th ed.). London: Pearson Education.

Simpson, M., Padmore, J., Taylor, N. and Frecknall-Highes, J. (2006). Marketing in small and medium-sized enterprises. *International Journal of Entrepreneurial Behavior & Research*, 12(6), 361–387.

Singh, J. and Singh, H. (2012). Continuous improvement approach: State-of-art review and future implications. *International Journal of Lean Six Sigma*, 3**,** 88-111.

Singhvi, S.S. (1986). Post-completion review for capital projects. *Planning Review*, 14(3), 37–39.

Suen, H., Cheung, S.O. and Mondejar, R. (2007). Managing ethical behaviour in construction organizations in Asia: How do the teachings of Confucianism, Taoism and Buddhism and globalization influence ethics management? *International Journal of Project Management*, 25**,** 257-265.

Uma, K.E. and Eboh, F.E. (2013). Corruption, economic development and emerging markets: Evidence from Nigeria. *Asian Journal of Management Sciences and Education*, 2**,** 56-67.

United Kingdom. The Comptroller and Auditor General. (2016). *Government's spending with small- and medium-sized enterprises*. London: National Audit Office.

Wahab, A.B. and Lawal, A.F. (2011). An evaluation of waste control measures in construction industry in Nigeria. *African Journal of Environmental Science and Technology*, 5**,** 246-254.

Woods, A. and Dennis, C. (2009). What do UK small- and medium-sized enterprises think about employing graduates? *Journal of Small Business and Enterprise Development*, 16(4), 642–659.

NIGERIAN CONSTRUCTION-RELATED PROFESSIONAL SERVICES FIRMS TO ADOPT LEAN CONSTRUCTION PRACTICES

Olajide OLAMILOKUN[1], Umar Datti YUSUF[2], and Emmanuel Dele OMOPARIOLA[3]

[1]Costimate Consulting, PO Box 404, Isolo, Lagos, Lagos State, Nigeria, Tel.: +234 803 492 0786, Email: jidous4ril@yahoo.com
[2]Department of Quantity Surveying, Bayero University, Kano, Kano State, Nigeria, Tel.: +234 803 649 4555, Email: yusufdatti@yahoo.co.uk, yudatti.qs@buk.edu.ng
[3]Department of Building Technology, Kogi State Polytechnic, Kogi State, Nigeria, Tel.: +234 806 554 1758, Email: felixdelly@yahoo.com

ABSTRACT

Studies have shown that construction projects are susceptible to problems such as low productivity, poor safety, inferior working conditions, insufficient quality, lack of timely communication and coordination amongst project stakeholders, and rising litigation. Adoption of lean construction (LC) principles within the manufacturing industry and other industries has led to notable improvement and resulted in improved time to market, reduced production costs, improved quality of the product, and active customer involvement. The study assessed the readiness of Nigerian construction-related professional services firms to adopt LC principles. The method of study involved a critical exposition of related literature, and use of the VERDICT readiness assessment model for analysis, and an ANOVA for readiness comparison. A structured questionnaire was issued for a sample size comprising 130 firms drawn from a finite population of 342 Nigerian construction-related professional services firms (project managers, architects, quantity surveyors, structural engineers, and M&E engineers) operating in Northern Nigeria. The findings of the study reveal that Nigerian construction-related professional services firms have process/project readiness to adopt LC principles, but that they do not have management, people and technology readiness to adopt LC principles. The study concludes that Nigerian construction-related professional services firms are not yet ready to adopt LC principles. The study recommends continuous awareness campaigns of LC principles and their potential benefits, via education and training to professional bodies, tertiary institutions offering construction-related programmes, and stakeholders in the construction industry.

Keywords: adoption, construction-related professional services firms, lean construction (LC), Nigerian construction industry, readiness

INTRODUCTION

Globally, the construction industry plays a key role in the economy of both developing and developed countries, contributing between 4% and 14% of the GDP, while generating a vast number of employment opportunities and wealth creation. However, until today, several countries are still facing a number of contingent problems, which should have been resolved. Koskela (2000) and LePatner et al. (2007) identify the problems that have been known to bedevil the construction industry as low productivity, poor safety, inferior working conditions, insufficient quality, lack of timely communication and coordination amongst project stakeholders, and rising litigation. The phenomenon of poor performance in construction has long been witnessed and recorded by academics and practitioners throughout the world, regardless of whether the country is developed, e.g. England (Eaton, 1994), or developing, e.g. Chile (Serpell et al., 1995). Thus, the UK government initiated reports, such as the Latham Report (Latham, 1994) and the Egan Report (Egan, 1998), both of which recommended the need for improvement of the construction industry's business performance.

The Nigerian construction industry is not immune to such problems, and it has been severely criticised for its inefficiency, low productivity, and lack of capacity to deliver and satisfy its clients. Oyewobi et al. (2011) attributed the drop in the Nigerian construction industry's contribution to GDP between 1980 and 2007 to poor performance and low productivity. Similarly, Idrus and Sodangi (2007) asserted that the Nigerian construction industry produces nearly 70% of the nation's fixed capital formation, yet its performance within the economy has been, and continues to be, very poor. Among the criticisms facing the industry are time and cost overruns (Kuroshi and Omorogbe, 2010; Ameh and Osegbo, 2011; Ogwueleka, 2011), inadequate planning and budgetary provisions, contract amount inflation, and inefficient and poor service delivery (Kolo and Ibrahim, 2010).

The need for greater coordination and integration within the industry has led to adoption of various concepts from other industries, such as partnering (Ibrahim and Price, 2006), concurrent engineering (Khalfan et al., 2001), technological innovations in design, and construction processes such as 3D, CAD, and modelling (Isikdag and Underwood, 2010; Olatunji et al., 2010; Abubakar, 2012). Lean construction principles are one of such innovative processes that bring about much-needed continuous improvement and desired change in the construction industry.

According to Dulaimi and Tanamas (2001), adoption of lean techniques in construction eliminates non-value steps, i.e. waste, it meets clients' demands better, and it dramatically improves architectural/engineering/construction (AEC) processes and products. Interestingly, unlike the case in Nigeria, lean techniques have been used with significant success in countries such as Singapore (Dulaimi and Tanamas, 2001), the UK (Common et al., 2000), Brazil (Da Silva and Cardoso, 1999), and Chile (Alarcón and Ashley, 1999). Thus, it is imperative for the Nigerian construction industry to exploit the widely acclaimed benefits of lean construction, in order to align its practice with global best practices, and to achieve the continuous improvement needed by its players in the industry.

However, because adoption of innovations such as lean construction principles usually brings about changes in the business processes and operational procedures of an industry or an organisation, there is a need to assess the level of readiness of the construction industry for lean construction implementation by

stakeholders' organisations, or by the entire construction industry, in order to continuously deliver value for money and effectively satisfy the needs of the client.

LITERATURE REVIEW

Lean construction principles

Lean construction has been defined in several ways by different authors. The most popular definition, by Koskela et al. (2002), states that lean construction is a way of designing production systems so as to minimise waste of materials, time, and effort, in order to generate the maximum possible amount of value. This approach is intended to cause developers, from the outset, to consider all aspects of the product life cycle, from conception through to disposal, including quality, cost, schedule, and user requirements. In the context of the construction industry, another definition states that lean construction is a holistic facility design and delivery philosophy, where the overarching aim is to maximise value to all stakeholders, through systematic, synergistic, and continuous improvements to contractual arrangements, product design, the construction process design and methods selection, the supply chain, and the workflow reliability of site operations (Abdelhamid, 2004).

Benefits of lean construction principles

Broadly speaking, lean construction has led to significant improvement in the performance of construction industry professionals, particularly in design, construction and facility management. Michigan State University (MSU) effectively benefits from lean construction twice – first as a client, and then on its own self-performed works – by saving on time and money, by improved quality of projects, by building relationships with service providers, and by providing value to end users, who otherwise are often not involved in the entire process. The following are some of the benefits of lean construction, as reported by Mossman (2009):

a. More satisfied clients;
b. Productivity gains;
c. Greater predictability;
d. Shorter construction periods;
e. Operatives are able to make better money;
f. Subcontractors are able to make better money;
g. Improved design;
h. Reduced costs, and less waste;
i. Improved safety and health, and
j. Improved quality, and fewer defects.

A case study conducted in the USA in 1998 shows remarkable benefits of implementing LC (Garnett, 1999): office construction times are reduced by 25% within 18 months, schematic design time is reduced from 11 weeks to 2 weeks, turnover is increased by 15% to 20% (Pacific Contracting), satisfied clients look to place repeat orders, and project costs are reduced.

Readiness assessment models

Readiness is a measure of the capability to adopt a new paradigm prior to its implementation. So many readiness assessment models have been developed in recent times for use in measuring readiness prior to adoption of a new paradigm.

Some of these tools include the one developed by Harvard University Center for International Development (CID, 2001), called the Networked Readiness Index, which gauges a country's ability to make use of its information and communication technology (ICT) resources. This index defines readiness as the degree to which a community is prepared to participate in the networked world, and its potential to be part of the networked world in the future (Kirkman et al., 2002). Similarly, the Asia-Pacific Economic Cooperation's (APEC) E-Commerce Readiness Assessment Guide focuses on government policies for e-commerce, while Mosaic's Global Diffusion of the Internet Project's readiness assessment tool aims to gauge and analyse worldwide growth of the Internet (Ruikar et al., 2006; Vaezi and Bimar, 2009).

While these tools are based on measuring readiness of countries, governments, and policies for adopting Internet technologies, there are other tools that focus on assessing readiness to adopt different engineering concepts and approaches. For example, SCALES (Supply Chain Assessment and Lean Evaluation System) was developed specifically for the manufacturing industry, in order to assess companies' (especially SMEs') readiness for adopting lean manufacturing techniques. There are several other tools that were developed for concurrent engineering (CE), such as RACE (Readiness Assessment for Concurrent Engineering), which was developed at West Virginia University in the United States in the early 1990s. RACE was conceptualised in terms of two major components: process, and technology. It is widely used in the software engineering, automotive and electronic industries (Ruikar et al., 2006). According to Khalfan and Anumba (2000), RACE can be modified to be used in construction and other industries. Similar to this tool is the SPICE (Standard Process Improvement for Concurrent Engineering) Questionnaire, which was developed at the University of Salford in the United Kingdom. It was designed to evaluate the key construction processes within construction organisations (SPICE Questionnaire, 1998). In addition, the BEACON (Benchmarking and Readiness Assessment for Concurrent Engineering in Construction) Model was created to evaluate the construction company's level of readiness for implementing concurrent engineering, with the aim of improving the project delivery process. Other tools include the Capability Maturity Model (CMM), developed for software development and evaluation, and the IQ Net Readiness Scorecard (Khalfan and Anumba, 2000; Ruikar et al., 2006; Aminali, 2007).

Another readiness assessment tool that is of particular relevance to this research is VERDICT (Verify End-user e-Readiness using a Diagnostic Tool), developed to assess the overall readiness of end users involved in the construction industry for using e-commerce technologies (Aziz and Salleh, 2011). The

VERDICT model is a combination of two e-readiness assessment models: the BEACON Model, and the IQ Net Readiness Scorecard. BEACON, as mentioned earlier, assesses the readiness of construction companies to improve their practices for implementing concurrent engineering. It consists of four elements: process, people, project, and technology. The IQ Net Readiness Scorecard is a web-based application developed by Cisco, based on a book called *Net ready*. Aminali (2007) assesses the readiness of IT service providers in such a way that the company is presented with statements that it has to judge, where the statements fall under four categories, namely leadership competency, governance competency, technological competency, and organisational competency. The average of the scores given will determine the company's e-readiness.

Similar methodology was adopted in developing the VERDICT model. In this model, the company is presented with statements that it has to judge, where the statements fall under four categories, namely management, process, people, and technology (Ruikar et al., 2006). The developers of VERDICT argued that to successfully implement any technology, there is a need to have people with adequate skills, understanding, and belief in the technology, then processes that enable and support successful adoption of the technology, then the technology tools and infrastructure necessary to support the business functions, and, lastly, consideration of management buy-in and belief. The next step is that management must believe in the technology and take strategic measures to drive its adoption, implementation, and use, in order to derive business benefits from the technology (Ruikar et al., 2006; Vaezi and Bimar, 2009). All the four elements have to work complementarily for any organisation to achieve readiness.

The developers claim that VERDICT can be used to assess the e-readiness of construction companies, departments within a company, or even working groups within a department. The assessment is performed by finding an average score for each of the four categories from the judgements of the respondents on the statements in the questionnaire. According to Ruikar et al. (2006):

- An average score greater than or equal to 0 and less than 2.5 shows a red colour, which indicates that urgent attention is needed to achieve e-readiness,
- An average score greater than or equal to 2.5 and less than 3.5 is an amber colour, which means that certain aspects need attention to achieve e-readiness, and
- An average score greater than 3.5 shows a green colour, which indicates that the organisation is adequately ready and mature enough for e-commerce tools.

The choice of these boundaries was based on simple average scores computed for each of the four elements in the questionnaire.

RESEARCH METHODOLOGY

The research methodology should clearly discuss the approach and/or the research design, data collection, and data analysis adapted or to be adapted in the research. One of the most important issues to be discussed here is the appropriateness of the

selected methodology, and whether it is the most appropriate choice compared to other alternatives. This is the opportunity for the authors to demonstrate their awareness and understanding (appropriate to the level of study) of the research tools commonly used in their field, and how this knowledge is used to inform them in constructing a robust methodology to tackle the research problems or questions.

This study made use of data and information collected with the aid of structured questionnaires which were administered in selected states in Northern Nigeria (specifically Kaduna and Kano states and Abuja (FCT)). In a study conducted by Dikko (2013), the total number of registered consulting firms with the Corporate Affairs Commission was shown to be 6,990, 34% of which are located in the northern part of the country. Making use of Yamane's (1967) sample size formula, i.e.

$$n = \frac{N}{1 + N(e)^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(1)}$$

where n = required sample size,
N = the population size, and
e = level of precision (0.050),
the sample size of the study was computed as 342.

The population for the study is construction-related professional services firms. They include project management firms, architectural design firms, structural design firms, mechanical and electrical engineering services design firms, and quantity surveying firms. The questionnaire was designed/structured based on the VERDICT readiness assessment model of Ruikar et al. (2006). Respondents were asked to select from responses on a five-point Likert rating scale (where 5 represents "strongly agree", and 1 represents "strongly disagree") the extent to which their firm conformed to the requirements of the VERDICT readiness assessment model. This was done to gain an objective indication of whether the findings identified in the literature review above are confirmed in practice.

A reliability analysis using the Cronbach's alpha was performed to determine the internal consistency, and thus the reliability, of the scale used in the survey questionnaire. The study utilised a number of descriptive statistical techniques to facilitate organisation, analysis and interpretation of the data. Means, standard deviations, and relative rankings were used.

FINDINGS AND DISCUSSION

Profile of the respondents

Of the 342 questionnaires administered, 130 (or 38%) of the total were returned and found appropriate for analysis. Moser and Kalton (1971) asserted that results of a survey can be considered reliable if the response rate is not lower than 30–40%. In view of this, the 38% response rate was considered adequate for purposes of analysis of the findings of the questionnaire. The purposive sampling method was adopted to ensure that only firms that are capable of providing the information required in the study were contacted.

Of the respondents, 27% were engaged in architectural design consultancy, 29% were engaged in quantity surveying consultancy, 21% were engaged in structural engineering consultancy, and 13% were engaged in project management consultancy. The remaining 10% of the respondents were engaged in mechanical and electrical engineering consultancy. The distribution of the respondents was representative of the major stakeholders in the industry. In terms of management level, 27% of the respondents belonged to the strategic/senior management level, 60% belonged to the middle management level, 8% belonged to the knowledge/lower management level, and 5% belonged to the operational level**.** In terms of work experience, 34% of the respondents had 16–20 years of experience, 24% had 11–15 years of experience, 22% had more than 20 years of experience, 15% had 6–10 years of experience, and 5% had less than 5 years of experience.

Assessment of the readiness of the various types of Nigerian construction-related professional services firms to adopt LC principles

Table 1: A summary of the average scores indicating the level of readiness of the various types of construction-related professional services firms

Professional services firms	Category	Average score	The situation, based on Ruikar et al.'s (2006) boundaries
Project management	Management	2.77	Amber
	Process/project	3.80	Green
	People	3.28	Amber
	Technology	3.18	Amber
Architectural design	Management	2.76	Amber
	Process/project	3.80	Green
	People	3.28	Amber
	Technology	3.23	Amber
Quantity surveying	Management	2.78	Amber

	Process/project	3.80	Green
	People	3.30	Amber
	Technology	3.26	Amber
Structural engineering	Management	2.77	Amber
	Process/project	3.84	Green
	People	3.28	Amber
	Technology	3.25	Amber
M&E engineering	Management	2.76	Amber
	Process/project	3.83	Green
	People	3.31	Amber
	Technology	3.27	Amber

(Source: Olamilokun et al., 2015)

The table presents average scores indicating the level of readiness of the various types of professional services firms in each category, i.e. management, process/project, people, and technology.

The average scores in all the categories except process/project were greater than 2.5 but less than 3.5 (amber) for all the various types of construction-related professional services firms considered in the study (project management, architectural design, quantity surveying, structural engineering, and M&E engineering firms in Nigeria). This clearly shows that project management firms, architectural design firms, quantity surveying firms, structural engineering firms, and M&E engineering firms in Nigeria all require attention on certain aspects to achieve management, people and technology readiness for adopting lean construction.

As shown in Table 1, for all the types of construction-related professional

services firms considered, process/project was the only category in which an average score greater than 3.5 (green) was obtained. This clearly indicates that project management firms, architectural design firms, quantity surveying firms, structural engineering firms, and M&E engineering construction-related professional services firms in Nigeria have adequate capability and maturity in this aspect, and that they are therefore ready to adopt new innovations.

The Cronbach's alpha computed to measure the internal consistency among the ratings of the respondents, as well as the reliability of the scales used for determining the readiness of construction-related professional services firms for adopting lean construction in the Nigerian construction industry, was very close to 1 (0.990), which indicates that the scales used were reliable, and that the respondents understood the questions that were presented to them in the questionnaire. The aforementioned findings corroborate the findings of Olatunji (2008), as they suggest that Nigerian construction-related professional services firms have a low level of awareness with regard to LC principles adoption.

Comparing readiness of the various types of Nigerian construction-related professional services firms to adopt LC principles

Table 2: Comparing readiness of the various types of Nigerian construction-related professional services firms to adopt LC principles

Descriptive								
	n	Mean	SD	Std error	95% confidence interval for mean		Min	Max
					Lower bound	Upper bound		
Project management	4	3.258	0.424	0.212	2.583	3.932	2.77	3.80
Architectural design	4	3.268	0.425	0.213	2.591	3.944	2.76	3.80
Quantity surveying	4	3.285	0.417	0.208	2.622	3.948	2.78	3.80
Structural engineering	4	3.285	0.438	0.219	2.589	3.981	2.77	3.84
M&E engineering	4	3.293	0.437	0.219	2.597	3.988	2.76	3.83
Total	20	3.278	0.381	0.085	3.099	3.456	2.76	3.84

ANOVA					
	Sum of squares	df	Mean square	F	Sig.
Between groups	0.003	4	0.001	0.005	1.000
Within groups	2.750	15	0.183		
Total	2.753	19			

(Source: Olamilokun et al., 2015)

A one-way ANOVA was conducted to determine if there is a significant difference between the levels of readiness of the various types of Nigerian construction-related professional services firms to adopt lean construction, based on the following hypotheses:

Null hypothesis (H_0): There is no significant difference in the level of readiness of the various types of Nigerian construction-related professional services firms to adopt lean construction.

Alternative hypothesis (H_1): There is a significant difference in the level of readiness of the various types of Nigerian construction-related professional services firms to adopt lean construction.

As shown in Table 2, the significance value is above 0.05 (1.00), which indicates clearly that the null hypothesis, which states that there is no significant difference in the level of readiness of the various types of Nigerian construction-related professional services firms to adopt lean construction, is accepted.

CONCLUSION AND RECOMMENDATIONS

The paper assessed the readiness of Nigerian construction-related professional services firms to adopt LC principles. The VERDICT readiness assessment model developed by Ruikar et al. (2006) was adopted and used for the assessment. The findings of the study show that Nigerian construction-related professional services firms have process/project readiness to adopt lean construction principles, but that they need to give attention to management, people and technology readiness, in order to achieve full readiness to adopt lean construction principles.

This study therefore clearly provides the Nigerian construction industry with useful information on the nature of improvement needed to set the scene for effective implementation of LC principles, and thus improve performance and productivity in the industry. The study also provides a basis for further research on factors inhibiting Nigerian construction-related professional services firms from attaining management, people and technology readiness to adopt LC principles.

The study recommends integrating LC principles in the architecture, construction and engineering sector, and creating more awareness of LC principles and their potential benefits, via education and training to professional bodies, tertiary institutions offering any construction-related programmes, and stakeholders in the construction industry in general. Also, government authorities responsible for construction and urban development are advised to promote the use of LC principles, as a strategic approach towards achieving continuous improvement in construction.

ACKNOWLEDGEMENT

This article was language-edited by a freelance language editor, Anthony Sparg. He has edited several academic journal articles and master's theses in the field of construction management. He has an MA *cum laude* in African Languages

(isiXhosa), an MA *cum laude* in Linguistics, and a Higher Diploma in Education.

REFERENCES

Abdelhamid, T. S. (2004). The self-destruction and renewal of lean construction theory: A prediction from Boyd's Theory. *Proceedings of the 12th Annual Conference of the International Group for Lean Construction*. 3–6 August. Helsingør, Denmark.

Abubakar, M. (2012). *An assessment of readiness of Nigerian building design firms to adopt building information modelling (BIM) technologies*. Unpublished MSc thesis. Ahmadu Bello University, Zaria, Nigeria.

Alarcón, L. F. and Ashley, D. B. (1999). Playing games: Evaluating the impact of lean construction strategies on project cost and schedule. *Proceedings of the 7th Annual Conference of the International Group for Lean Construction*. 26–28 July. University of California, Berkeley, CA.

Ameh, O. J. and Osegbo, E. E. (2011). Study of relationship between time overrun and productivity on construction sites. *International Journal of Construction Supply Chain Management*, 1(1), 56–67.

Aminali, P. (2007). *e-Readiness assessment within the Iran's automotive industry: Case of Iran Khodro Industrial Group*. MSc thesis. Department of Business Administration and Social Sciences, Luleå University of Technology, Luleå, Sweden.

Aziz, N. M. and Salleh, H. (2011). A readiness model for IT investment in the construction industry. *African Journal of Business Management*, 5(7), 2524–2530.

Common, G., Johansen, E. and Greenwood, D. (2000). A survey of the take-up of lean concepts among UK construction companies. *Proceedings of the 7th Annual Conference of the International Group for Lean Construction*. Brighton, UK.

Da Silva, F. B. and Cardoso, F. F. (1999). Applicability of logistics management in lean construction: A case study approach in Brazilian building companies. *Proceedings of the 7th Annual Conference of the International Group for Lean Construction*. 26–28 July. University of California, Berkeley, CA.

Dikko, K. (2013). Establishing status of Nigerian building design firms based on European Construction Institute Total Quality Management matrix. In: Smith, S.D. and Ahiaga-Dagbui, D.D. (eds). *Proceedings of the 29th Annual Association of Researchers in Construction Management (ARCOM) Conference*. 2–4 September. Reading, UK: ARCOM. pp. 1037–1046.

Dulaimi, M. F. and Tanamas, C. (2001). The principles and applications of lean construction in Singapore. *Proceedings of the 9th Annual Conference of the International Group for Lean Construction*. 6–8 August. National University of Singapore, Singapore.

Eaton, D. (1994). Lean production productivity improvements for construction professionals. In: L.F. Alarcón (ed.). *Lean construction.* Rotterdam: A.A. Balkema. pp. 279–289.

Egan, J. (1998). *Rethinking construction: Report of the Construction Task Force*. London: CIB.

Garnett, N. A. (1999). Developing lean thinking in construction: A naturalistic enquiry. *Proceedings of the 7th Annual Conference of the International Group for Lean Construction*. 26–28 July. University of California, Berkeley, CA.

Ibrahim, A. D. and Price, A. D. F. (2006). The development of a continuous improvement framework for long-term partnering relationships. *Journal of Financial Management of Property and Construction*, 11(3), 149–163.

Idrus, A. B. and Sodangi, M. (2007). Framework for evaluating quality performance of contractors in Nigeria. *International Journal of Civil & Environmental Engineering IJCEE-IJENS*, 10(01), 34-39.

Isikdag, U. and Underwood, J. (2010). A synopsis of the handbook of research on building information modelling. *Proceedings of the 18th CIB World Building Congress*. 10–13 May. The Lowry, Salford Quays, UK. pp. 84–96.

Khalfan, M. M. A. and Anumba, C. J. (2000). Readiness assessment for concurrent engineering in construction. *Proceedings of the Bizarre Fruit 2000 National Conference of Postgraduate Research in the Built and Human Environment*. 9–10 March. University of Salford, Salford, UK. pp. 42–54.

Khalfan, M. M. A., Anumba, C. J. and Carrillo P. M. (2001). Development of a readiness assessment model for concurrent engineering in construction. *Benchmarking: An International Journal*, 8(3), 223–239.

Kirkman, G. S., Osorio, C. A. and Sachs, J. D. (2002). *The Networked Readiness Index: Measuring the preparedness of nations for the networked world*. Cambridge, MA: Center for International Development (CID), Harvard University.

Kolo, B. A. and Ibrahim, A. D. (2010). Value management: How adoptable is it in the Nigerian construction industry? In: Laryea, S., Leiringer, R. and Hughes, W. (eds). *Proceedings of the West Africa Built Environment Research (WABER) Conference*. 27–28 July. Accra, Ghana. pp. 653–663.

Koskela, L. (2000). *An exploration towards a production theory and its application to construction*. Espoo, Finland: VTT Technical Research Centre of Finland.

Koskela, L. and Howell, G. (2002). The underlying theory of project management is obsolete. *Proceedings of the PMI Research Conference*. June. Seattle, WA. pp. 293–302.

Kuroshi, P. A. and Omorogbe, N. E. (2010). BIM enabled system of expenditure control for construction projects. *Working paper proceedings of the Engineering Project Organizations Conference*. 4–7 November. South Lake Tahoe, CA.

Latham, M. (1994). *Constructing the team. Joint review of procurement and contractual agreements in the United Kingdom construction industry. Final report*. London: HMSO.

LePatner, B. B., Jacobson, T. C. and Wright, R. E. (2007). *Broken buildings, busted budgets: How to fix America's trillion-dollar construction industry*. Chicago: University of Chicago Press.

Moser, C. A. and Kalton, G. (1971). *Survey methods in social investigation*. London: Heinemann Educational.

Mossman, A. (2009). "There really is another way, if only he could stop … for a moment and think of it"—Why isn't the UK construction industry going lean with gusto? *Lean Construction Journal*, 24–36.

Ogwueleka, A. (2011). The critical success factors influencing project performance in Nigeria. *International Journal of Management Science and Engineering Management*, 6(5), 343–349.

Olatunji, O. J. (2008). Lean-in-Nigerian construction: State, barriers, strategies and "Go-to-Gemba" approach. *Proceedings of the 16th Annual Conference of the International Group for Lean Construction*. 14–20 July. Manchester, UK.

Olatunji, O. J., Sher, W. D., Gu, N. and Ogunsemi, D. R. (2010). Building information modelling processes: Benefits for construction industry. *Proceedings of the 18th CIB World Building Congress*. 10–13 May. The Lowry, Salford Quays, UK. pp. 137–151.

Oyewobi, L. O., Ibironke, O. T., Ganiyu, B. O. and Ola-Awo, A. W. (2011). Evaluating rework cost- A study of selected building projects in Niger State, Nigeria. *Journal of Geography and Regional Planning*, 4(3), 147–151.

Ruikar, K., Anumba, C. J. and Carrillo, P. M. (2006). VERDICT—An e-readiness assessment application for construction companies. *Automation in Construction*, 15(1), 98–110.

Serpell, A., Venturi, A. and Contreras, J. (1995). Characterization of waste in building construction projects. In: L.F. Alarcón (ed.). *Lean construction*. Rotterdam: A.A. Balkema. pp. 67–77.

SPICE Questionnaire (1998). *Key Construction Process Questionnaire Ver. 1.0*. July. Salford University.

Vaezi, S. K. and Bimar, H. S. (2009). Comparison of E-readiness assessment models. *Scientific Research and Essay*, 4(5), 501–512.

Yamane, T. (1967). *Statistics: An introductory analysis*. New York: Harper & Row.

THE INFLUENCE OF CULTURE, BELIEFS AND EXPERIENCE ON THE SUSTAINABLE END-OF-LIFE MANAGEMENT OF BUILDINGS IN NIGERIA

Aminu Lawan ABDULLAHi [1] and Angela LEE[2]

[1] Department of Architecture, Kano University of Science and Technology (KUST), Nigeria, Email: Aminu.abdullahi@hud.ac.uk
[2] School of Art, Design and Architecture, University of Huddersfield, UK, Email: a.lee@hud.ac.uk

ABSTRACT

While it is usually believed that economic incentives are behind waste management practices in developing countries, this article discusses culture, belief and experience as the other major influences in the management practices of building demolition waste in Nigeria. Practitioners in the building demolition sub-sector were interviewed to identify the influences that contribute to the emergence of reuse as a preferable demolition waste management technique in society, in addition to the economic incentives. This study will give an insight into some practices in a pre-industrial society with potential for recognition and contribution of the development of formal waste management systems in developing countries.

Keywords: building demolition waste, Kano, Nigeria, non-economic factors, culture, beliefs

INTRODUCTION

As stated by the Royal Institute of Architects, sustainability is indeed man's major issue of the 21st century (RIBA, 2009a, 2009b, 2009c, 2009d). This is even more pertinent when considering examples from history from a number of pre-industrial societies that collapsed as a result of the unsustainable exploitation of the environment described by Diamond (2005) as "ecocide". Some of these societies include the Maya cities in Central America, the Great Zimbabwe in Africa, the Mycenaean Greece in Europe, and Easter Island in the Pacific Ocean (Diamond, 2005). As demonstrated in the Biosphere 2 experiment (Rogers, 2011), present societies face the same environmental problems as past societies, with additional challenges. According to Diamond (2005), the eight environmental challenges similarly faced by past societies can be categorised into deforestation, soil erosion, water scarcity, overhunting, overfishing, population growth, and increased human impact per capita. Nevertheless, four other threats not found in past societies are human-induced climate change, toxic chemicals in the environment, energy shortages, and exhaustion of the photosynthetic capacity of the earth (Diamond, 2005). These latter four threats are the consequences of the introduction of machinery and the development of industry driven by

fossil fuel consumption and rapid natural resources extraction. These consequences include the degradation of the natural environment and new social phenomena such as population increase and urbanisation, consumerism and solid waste generation, and a new order for social stratification in society (Chappine, 2015).

In the built environment, according to Morris (2013), before the Industrial Revolution buildings were typically vernacular and made from locally available materials and technology. Nevertheless, as described by Hawkes (2011), in England for example, unsustainable architecture replaced vernacular architecture from the inception of the Industrial Revolution. New construction methods utilising glass and steel as products of the Industrial Revolution emerged (Hawkes, 2012). However, it was also was realised at this time that that the continued unsustainable exploitation of nature beyond its capacity should either be stopped by choice, or would be forced by natural consequences (Meadows, Meadows, Randers and Behrens, 1972), including the possibility of the extinction of the human race (Mark, 2000).

The built environment is one of the sectors central to the sustainability agenda owing to its huge environmental impact. The vernacular architecture once adapted to the natural environment has been replaced by buildings that rely on the supply of unsustainable energy generated from fossil fuels for the running of the newly introduced mechanical services (Banham, 1969) However, an energy conscientiousness has emerged since the 1970s and 1980s (Hawkes, 2013).

The negative contribution of buildings to global warming starts with the embodied "energy" consumed in the manufacturing of the building materials and proceeds to the stages of construction, operation, and ultimately, demolition (Berge, 2009). Buildings are responsible for 70% of the energy consumption (Brandon and Lombardi, 2011), nearly half of the estimated 560 million carbon emissions in the United Kingdom (UK) (RIBA, 2009b, 2009c, 2009d), and 30% of the global emission (Belogolovsky, 2009). The impact of buildings is not only limited to energy consumption and carbon emission, but also extends to 40% of the global acid rains (Belogolovsky, 2009), natural ecological imbalance, fresh water depletion, land usage, and solid waste (Kibert, 2005). It is acknowledged that 90% of all materials ever extracted may be residing in the built environment (Kibert, 2005).

Furthermore, many of these materials are returned to the earth as waste with the associated negative impacts in a pattern described by McDonough and Braungart (2009) as cradle-to-grave. In the UK alone, an alarming figure of annual 90-120 million tonnes of waste are associated with construction and demolition (C&D), with more than 10% of unused materials as disclosed by government sources (Osmani, 2012; UK Green Building Council, 2013). This makes the built environment central in the need for optimal utilisation of resources (Dasgupta and Heal, 1979). Subsequently, a solution to the solid waste generated from the demolition of buildings at the end of their usefulness will be a move towards addressing one of the major sustainability challenges facing humanity: the risk of resources exhaustion. One possible approach to achieve this objective is for construction to learn from other sectors, an idea advocated by Latham (1994), Egan (1998) and others as cited by Keraminiyage (2009) and Lee (2002). However, if construction must learn from any other sector, the best of such other sectors for lessons in the management of waste are natural ecological systems.

In natural ecological systems there is no waste, rather an inter-dependent relationship among different species. The droppings from animals, for instance, are utilised as nourishment for plants, and the carrion left behind by predatory animals is a ready-made meal for scavengers (Bishop, 1973). Consequently, no waste is generated; the potential waste from one organism

becomes a raw material for another in a closed-loop cycle, or what McDonough and Braungart (2009) term as cradle-to-cradle. Additionally, the natural ecosystem utilises renewable solar energy, organic storage systems, segmented operations, efficiency, interdependencies between systems, and adaptation. Thus, the question arises whether the construction industry can be organised in the same kind of natural ecological system with zero waste output.

This is the subject discussed by Kibert, Sendzimir and Guy (2000), who propose a conceptual reorganisation of the construction industry to operate in line with the principles of natural ecology as well as in harmony with the natural environment under the tag/label of construction ecology. The three tenets of construction ecology are the closed-loop material cycle, the use of renewable energy, and the conservation of nature. The idea of construction ecology is adopted from the biomimetic concept of industrial ecology, whereby human economic activities are organised in the style of nature with the by-product of one process used as the raw material for another process (Odum, 1993). Industrial ecology is a widely accepted concept that was recognised as the main theme of the national technology strategy policy of Clinton's administration in the United States of America (USA) (Benyus, 1997). The popularity of the industrial ecology concept as an analogy to the natural ecology suggests a recognition of the superiority of the natural systems over artificial systems.

Similarly, the question can be asked where there is a human system that resembles the natural ecological system in its operations and interrelation of its constituent sectors; where such a system produces zero waste; and where a by-product from one operation becomes the raw material for another. What if such a system emerges naturally without systematic efforts and being policy driven? Then it can be argued that such a system is more favourably in line with the sustainability thinking than other systems that exhibit fewer characteristics of the natural systems. While the resemblance of the Nigerian practice of the end-of-life management of buildings to the natural ecological system is a subject of yet another discourse, the research inquiry in this article examines the influences of culture, beliefs and experience on the Nigerian system of building demolition waste management.

RESEARCH CONTEXT

Despite many subdivisions among cultures and regions, Nigerian society is mainly divided between the north and the south and this dichotomy is reflected in virtually all aspects of political, cultural, and economic life. Discussions of Nigerian cities are sometimes approached according to this line of cultural dichotomy (Phillips, 2003, 2004). Nevertheless, the Township Ordinance of 1917 was motivated by the complexities and heterogeneous nature of the townships that make administration too challenging for the native administration to handle. Thus, the townships were classified into first-, second-, and third-class townships (Olukoju, 2004). First-class townships were administered by a council, while an administrator assisted by an advisory board was nominated for the second-class townships. According to the Nigerian Township Ordinance, there were eighteen second-class townships and despite the emergence of more post-colonial townships (Olukoju, 2004), these remain major settlements and population centres to the present day. Lagos was the only first-class township administered by a council in line with its unique nature.

Figure 1: Major townships in Nigeria (Source: CIA [The World Factbook], 2017)

Lagos may probably be one of the ten most populous cities in the world by 2025 (Phillips, 2003). It is largely made up of four islands interconnected by bridges that are barely adequate for the large population it accommodates. Characterised by pollution, crime and overcrowding, Lagos was once a state and federal capital city with limited capacity for expansion (Chattopadhyay and Slack, 2009; Phillips, 2003, 2004). This unique nature of Lagos was cited as the reason for relocating the federal capital city to Abuja, based on the recommendation of a panel, subsequent military decrees and implementation. The peculiar nature of Lagos places it in a class of its own: it is not representative of a typical Nigerian city, and therefore considered unsuitable as a site for this study.

The site for the new capital city of Nigeria, namely Abuja, was purposely selected for its geographical location, climate and neutrality, and was designed and built as a modern administrative city (Chattopadhyay and Slack, 2009; Phillips, 2003, 2004). Predominantly developed by the government to accommodate administrative office buildings and residences for the bureaucrats, Abuja is in a class of its own and cannot be representative of a typical Nigerian city; therefore, it is equally excluded from consideration for the study site of this research.

According to the National Population Commission (2010) and the National Population Commission (2016), Kano is the second most populated city in Nigeria and the most populous among the second-class townships recognised by the Township Ordinance of 1917. The city of Kano has a heterogeneous composition (Olukoju, 2004), and currently remains a vibrant commercial and cultural centre. Moreover, as described by Urquhart (1977), four different types of settlements with official recognition emerged in the urban centres of northern Nigeria. These were the ancient walled city usually left intact, the European official settlements popularly known as GRA (an acronym for Government Reserved Area), the *Tudun Wada*, a settlement for non-indigenous northerners, and the *Sabon Gari*, the living quarter for settlers from southern Nigeria (Urquhart, 1977). This structure still exists in Kano and makes the city a confederation of all Nigerian nationalities. Subsequently, this became a

tradition that can be observed even in recently developed settlements as demonstrated in more recent news reports such as: "Witnesses say…in the mainly Christian area of Sabon Gari" (BBC, 2014).

Therefore, the subject of this investigation is the serendipitous discovery of Kano. Kano was selected as the study site for three reasons, namely population, heterogeneity, and the identification of the phenomenon. Moreover, in a qualitative inquiry of this nature, the subject of study may be determined by who or what satisfies the interests of the research (Baker and Edwards, 2012).

RESEARCH METHOD

The practices of handling demolition waste as a concurrent phenomenon and the concept of the industrial ecology as theoretical presupposition qualify this study to use a case study strategy. As described by Yin (1981, 2009) , a case study is a synchronous study of situations whereby the subject is not distinct from the context without the researcher's control over events. Similarly, the researcher has no control over the variables in the building demolition waste management practices in the Nigerian cities. Moreover, a case study is considered convenient for exploratory and descriptive inquiries that seek to answer the 'How?' and 'What?"' questions as in this research.

The unit of analysis in this research is the community of *Yangwangwan*, referring in the local Hausa language to the group of stakeholders dealing with salvaged building materials of Kano city. Active players in the industry with first-hand experience in at least one building demolition project were selected to participate in this research. Such informative persons were expected to identify a further three participants for the research in a snowball fashion; however, while in the field, this was seldom practical. Therefore, 75% of the research participants were identified directly by the researcher. An equal quota of three (3) participants from each of the seven (7) stakeholder groups was expected to form the sample for the research, but this was equally impractical whilst in the field as some of the participants belonged to more than one stakeholder group, and the willingness and availability of the participants could not be obtained evenly across the stakeholder groups. A total of 16 participants across all the stakeholder groups participated in the research (see Figure 2 for the selection process).

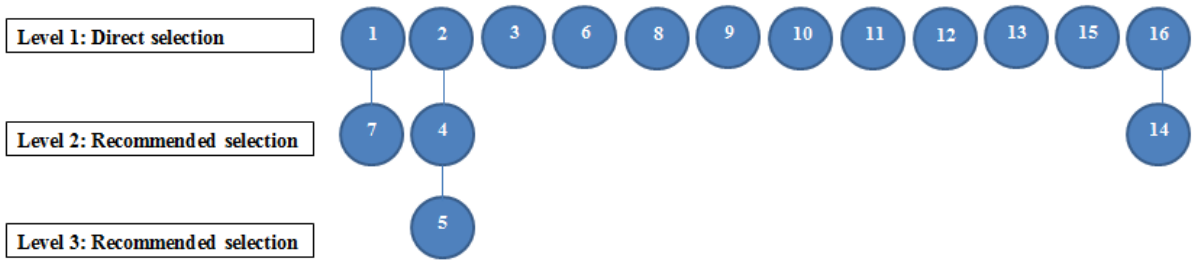

Figure 2: Selection of research participants

Information was obtained from the research participants through a semi-structured in-depth interview guided by a priori themes developed from the best practices of waste management across sectors with the emphasis on lessons from natural ecological systems. In addition, information was solicited from real-life projects in which the research participants had played an active role. Thereafter, the interviews were transcribed verbatim for analysis using a qualitative data analysis application, namely QDA Miner.

The sub-themes of the interviews included the following:

- Narrative of the processes of building demolition from experience,
- The stakeholders and their roles,
- Challenges,
- Improvements,
- Historical evolution,
- Health and safety, and
- Influencing factors.

However, another variation of the thematic analysis procedure is the template analysis that was described by its proponent as being flexible for use in different research scenarios, more especially with presumptive themes, otherwise referred to as a priori themes (Brooks and King, 2014; King, 2012). The main feature of template analysis is a flexible coding template that may be developed without the need to comply to any rigid format or differentiation between descriptive and interpretive data. The a priori themes were applied to structure the initial inquiry according to some theoretical concerns of particular importance in relation to the topic. The flexibility of the template analysis allows for new emergent themes to be incorporated.

The discussion in this article is limited to the relevance of culture, beliefs and experience in the management of materials at the end of service of a building as emergent themes, and the key findings of this research are presented as follows.

RESEARCH FINDINGS

Five of the 16 interviewees representing 31% of the participants highlighted that culture and belief are two of the factors that influence the prevalence of the reuse of salvaged building materials in society. While participants EN3, EN7 and EN16 mentioned culture without explanation, other participants, namely EN14 and EN13, discussed it in more detail. According to participant EN14, "Some people have this belief, the older the material, the better are the materials! You find that you can salvage even the blocks from older buildings [sic]". Similarly, participant EN13, who has more than 30 years' work experience in the construction industry in a different capacity, said: *"*The older the material is, the more probability that it will be of higher quality. You will realise that the most recent materials are even destroyed in the process of decommissioning, therefore, they are less valuable [sic]" (EN13). He went further to elaborate on this point as follows:

> *"…that is what I said - if what the stakeholder wants is aesthetics, then definitely newer materials from decommissioning may be valuable, but where quality is considered, the older ones are better. It is logical that if a building material can last for fifty years in a building and is still in good condition, it means the quality is tested and trusted. There is a probability that it will last for more years. Even the manufacturer of that components will enjoy preference for even the new materials he is making now; his products have been tested and even among the newer products now, his own will be more valuable. He has established goodwill with the public - his product has been tested and trusted [sic]".*

The possible interpretation and implications of these remarks form the research participants are presented in the following discussion.

DISCUSSION

The influence of culture and tradition

Culture is defined as "…the collective programming of the mind which distinguishes members of one group or category of people from another" (Geert and Jan, 1991). There is a correlation between environmental sustainability and the national culture as mentioned in the writing of Park, Russell, and Lee (2007), as there is in theories of management, employee motivation, leadership, organisational structure, planning and problem- solving approaches (Hofstede, 1980, 1984). Similarly, the remarks of the research participants can be interpreted to suggest the influence of culture, belief and experience in the choice of waste management techniques to adopt in deciding the fate of materials at the end of service.

There is an old custom among the Hausas described by Schwerdtfeger (1982) whereby a dead person is buried in or around his or her room and the buildings is allowed to collapse naturally over time. The timbers from the roof are reused for a new building or as firewood, while the mud and the space of the collapsed structure are used in making bricks and rebuilding another room for the next generation. It can be speculated that this culture might possibly have persisted and unconscientiously influenced the choice of reusing building materials among the present day generation of the Hausas in Nigeria. Moreover, the Hausas are renowned for their conservative attitudes in many respects (Adamu, 2006; Callaway, 1987; Whitsitt, 2003). A study in West Africa classified Hausas along with other short-term orientation societies associated with the attribute of respect for traditions (Geert and Jan, 1991).

Another aspect of the Hausa culture that may come into play are the informal traditional housing and finance that provide most of the housing stock for the Hausas and probably Africa in general. The Hausas live in patrilocal communities organised in co-residential kinship groups in which family heads are expected to self-build and provide residential accommodation for their families, sometimes with some contributions from members of the kinship (Schwerdtfeger, 1982). This culture is further reinforced by the collapse of the official housing policy (Ogunshakin and Olayiwola, 1992), and myriads of other challenges facing the housing sector in Nigeria (Akeju, 2007). In order to meet with the obligation of providing shelter for the family in the midst of scarce resources, the reuse of salvaged building materials may provide an easier option.

In the context of demolition waste management, culture and tradition encourage the prevalence of reuse of the salvaged building materials in yet another building or for other purposes, not necessarily in the construction sector. In an analogy for the natural ecological systems, waste from one building becomes a raw material for use in another building or other sectors, thereby eliminating any waste. This is a practical form of industrial ecology. Moreover, reuse of materials is considered the second most sustainable waste management strategy in line with the principle of the waste hierarchy and the EU directive on waste management (DOE, 2012; Kibert, 2005; Nowak, Steiner and Wiegel, 2009). Therefore, this culture is worthy of recognition and integration into the formal waste management systems for its contribution to the sustainable utilisation of resources.

Beliefs

A*rgumentum ad antiquitatem*, meaning 'appeals to antiquity', is a common belief among the Hausas that may have contributed to the choice of the reuse technique for building demolition waste management. The Hausas believed that the older a material, the better its quality. This

philosophy may be a fallacy; nevertheless, it reinforces the culture of reusing salvaged building materials as well as attracting economic value to the materials.

A common proverb in the Hausa language most often cited to support older items as more valuable says, *Da tsohuwar zuma a ke magani,* meaning 'Only an old honey can cure*'*. The reasons for the prevalence of this philosophy may be beyond the scope of this article; however, this philosophy is friendly to the environmental sustainability agenda. It is contrary to the unsustainable fashion and trend psychology in other societies whereby a temporary seasonal cyclical phenomenon is adopted temporarily and discarded just as quickly (Bhardwaj and Fairhurst, 2010).

Experience

In the fields of psychology and sociology the after-effect of especially negative experience on future human behaviour is a well-established area of study (Cook et al., 2005). Nevertheless, the relationship between experience and consumer behaviour in the context of environmental management may be another area that requires further study. In this study, there is a pattern that is illustrative of such a relationship between collective consumer experience, consumer behaviour and the management of materials from decommissioned buildings. The philosophy of prioritising older over new building materials may be explained by the transition of the Nigerian consumer market from the British standard goods to the Chinese sub-standard products that flood the market (Falola and Achberger, 2013; Raine, 2013). In Nigeria, labelling a product as being made in China is synonymous with low quality. This psychology of Nigerian consumers was the subject of public discussion among Nigerian citizens as well as a concern for the authorities of the two countries (Agency Report, 2015; Okafor, 2015). An experience of a generation of post-colonial stakeholders that witnessed the transition from the high-performing British standards products to the poor-performance newly introduced sub-standard Chinese building materials may be inclined to reinforce the notion of "the older, the better in quality". Moreover, these stakeholders cannot easily divorce themselves from the influence of their native culture and beliefs. Statements as cited above should therefore not be unexpected. Therefore, this collective experience of the entire society might have further reinforced the culture and belief in the superior quality of the older over new building materials.

Figure 3 represents the interplay of these factors in reinforcing the prevalence of the sustainable practice of reuse of salvaged building materials in the Nigerian society of Kano.

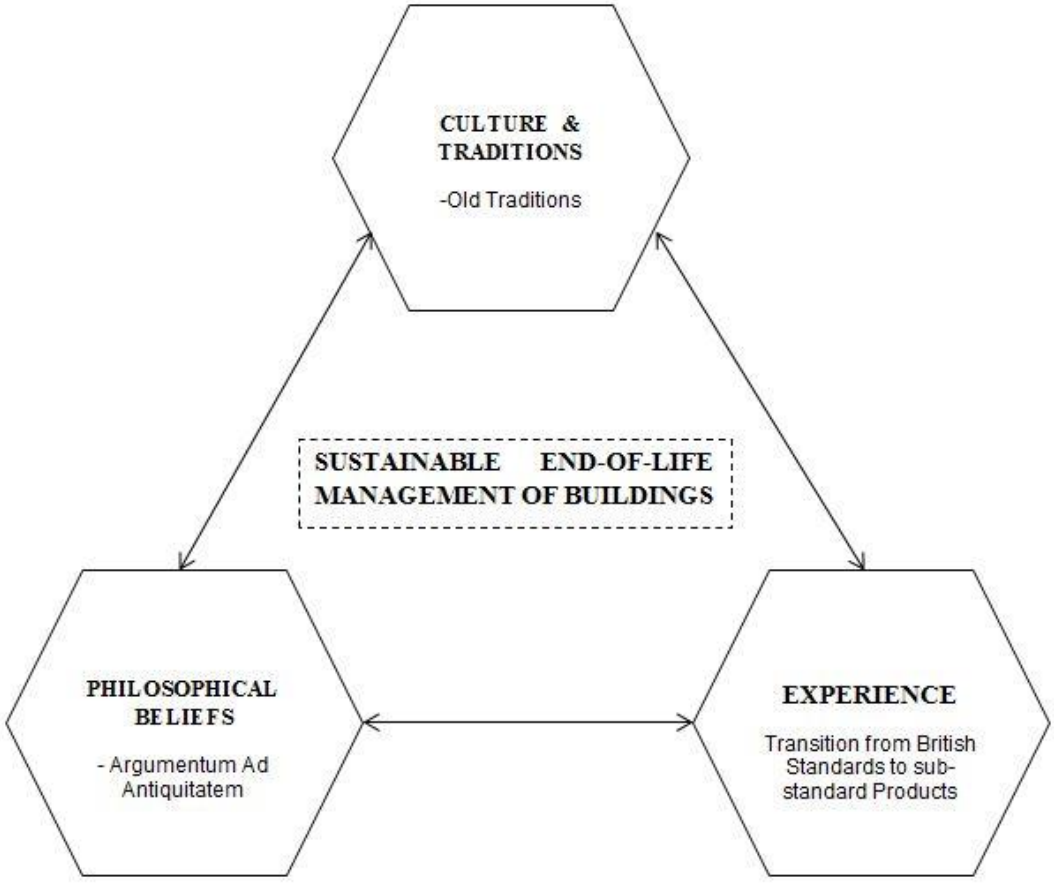

Figure 3: Influence of culture, beliefs and experience on sustainable end-of-life management of buildings

CONCLUSIONS

Sustainability is indeed man's major issue of the 21st century (RIBA, 2009d). Conferences and summits have been organised on sustainability at various levels, some attended by over a hundred world leaders (Brandon and Lombardi, 2011). Despite some initial resistance by developing countries (Najam, 2005), it was later accepted as a global agenda to pursue development for the satisfaction of the current generation without jeopardising the feasibility of the same privilege for the future generations (Brundtland, 1987). Global warming and resources consumption are among the most critical issues in the sustainability debate; therefore, this positions the built environment among the central issues of focus as probably the largest contributor to both global warming and resources consumption.

The search for solutions for construction may include looking into other sectors such as the natural systems. Nevertheless, the wisdom of respecting nature as a teacher is inherent among some of the native societies (Benyus, 1997). While historical evidence suggests on the one hand that there were societies that arguably collapsed from human-induced ecological catastrophe (Flenley and Bahn, 2007; Hunt, 2007; Mieth and Bork, 2010), on the other hand, there were success stories of a number of pre-industrial societies such as Tokugawa Japan and Tikopia that were able to manage the ecology sustainably and survived for thousands of years. These success stories suggest that there may be an abundance of lessons to be learnt from these cultures even by present-day societies (Diamond, 2005). Nonetheless, when discussing waste management policies at an international level, the typical approach is to

dismiss the waste management techniques in developing countries as informal and primarily driven by economic incentives (Schneider and Ragossnig, 2014).

This article advocates a paradigm shift and argues that looking beyond the surface of these cultures with a different motive of finding inspirations for sustainable solutions is likely to be more revealing. As argued by Husted (2005), culture must be included in addition to economy for a complete discussion of sustainability. Diamond (2005), in his frequently cited book on how societies chose to fail or succeed, identified religious beliefs as one of the factors that prevented the doomed societies from realising the catastrophe ahead of them while destroying their ecosystem. The Moai statues that the prehistoric Easter Islanders were competing to erect despite the negative consequences to their resource base were a manifestation of the influence of belief.

Consequently, this article discusses other driving factors which are beyond economics and which are behind the sustainable practices in a preindustrial society i.e. the cultural attitudes, traditions of respecting and reusing materials in building constructions, and experience. In line with sustainability thinking, this culture is more favourable than the trend and fashion culture prevalent in contemporary affluent societies. Even in advanced countries the practice of reusing building materials is now gathering momentum, as evidenced in the advocacy for recycle aggregates in concrete, new life for old wood, the mission of the American Construction and Demolition Recycling Association, and some private corporations (Brito and Saikia; CDRA, 2016; Fast, 2001; Kibert, 1993; Pacheco-Torgal et al., 2013; Sassi, 2008), hence the return to the long established practices in some of the preindustrial societies.

ACKNOWLEDGEMENT
Appreciation to the Nigerian Tertiary Education Trust Fund (TETFUND) for sponsorship of the PhD programme that led to this publication.

References

Adamu, Y. (2006). Loud bubbles from a silent brook: Trends and tendencies in contemporary Hausa prose writing. *Research in African Literatures,* 37(3), 133.

Agency Report. (2015). Africans task China on fake, sub-standard products in African markets. *Leadership*. Available at: http://leadership.ng/news/435334/africans-task-china-on-fake-sub-standard-products-in-african-markets

Akeju, A. A. (2007). Challenges to providing affordable housing in Nigeria. *Proceedings of 2nd Emerging Urban Africa International Conference on Housing Finance.* 17-19 October. Abuja, Nigeria.

Baker, S. E. and Edwards, R. (eds.). (2012). How many qualitative interviews is enough. *Working paper*. National Centre for Research Methods, University of Southampton.

Banham, R. (1969). *The architecture of the well-tempered environment*. London: Architectural Press.

Belogolovsky, V. (2009). *Green house*. Yekaterinburg, Russia: Tatlin Publishers.

Benyus, J. M. (1997). *Biomimicry : Innovation inspired by nature*. New York: Morrow.

Berge, B. (2009). *The ecology of building materials* (2nd ed.). Oxford: Elsevier/Architectural Press.

Bhardwaj, V. and Fairhurst, A. (2010). Fast fashion: Response to changes in the fashion industry. *The International Review of Retail, Distribution and Consumer Research,* 20(1), 165-173.

Bishop, O. N. (1973). *Natural communities*. London: J. Murray.

Brandon, P. S. and Lombardi, P. L. (2011). *Evaluating sustainable development in the built environment* (2nd ed.). Oxford: Wiley-Blackwell.

British Broadcasting Corporation (BBC). (2014). *Nigeria's Boko Haram crisis: Kano suicide attack.* Available at: http://www.bbc.co.uk/news/world-africa-27465113

Brooks, J. and King, N. (2014). Doing template analysis: Evaluating an end-of-life care service. *Sage Research Methods Cases*. London: Sage.

Brundtland, G. H. (1987). *Report of the World Commission on Environment and Development:" Our common future."* Oslo: United Nations.

Callaway, B. J. (1987). *Muslim Hausa women in Nigeria: Tradition and change*. New York: Syracuse University Press.

Central Intelligence Agency (CIA) (2017). Africa - Nigeria. *The World Factbook.* Available at: https://www.cia.gov/library/publications/the-world-factbook/geos/ni.html

Chappine, P. (2015). *Urbanization and other effects of the Industrial Revolution: Social and economic impacts.* Available at: http://study.com/academy/lesson/urbanization-and-other-effects-of-the-industrial-revolution.html

Chattopadhyay, R. andSlack, N. E. (2009). Finance and governance of capital cities in federal systems. *Forum of Federations/Forum des Féderations.* Montreal: McGill-Queen's University Press.

Construction and Demolition Recycling Association (CDRA). (2016). *Welcome to the CDRA*. Available at: http://www.cdrecycling.org/Cook, A., Spinazzola, J., Ford, J., Lanktree, C., Blaustein, M., Cloitre, M. and Van der Kolk, B. (2005). Complex trauma. *Psychiatric Annals,* 35(5), 390-398.

Dasgupta, P. S. and Heal, G. M. (1979). *Economic theory and exhaustible resources*. Cambridge: Cambridge University Press.

De Brito, J. and Saikia, N. *Recycled aggregate in concrete : Use of industrial, construction and demolition waste*. London: Springer-Verlag.

Diamond, J. (2005). *Collapse: How societies choose to fail or succeed*: New York: Penguin.

.

Falola, T. and Achberger, J. (2013). *The political economy of development and underdevelopment in Africa,* 10. London: Routledge.

Fast, E. (2001). New life for old wood. *Environment,* 43(2), 4-5.

Federal Republic of Nigeria. National Population Commission. (2010). *Priority Table Volume III: Population distribution by sex, state, local government, and senatorial district*. Available at: http://www.population.gov.ng/images/Vol 03 Table DSx LGAPop by SDistrict-PDF.pdf

Federal Government of Nigeria. National Population Commission. (2016). *Censuses.* Available at: http://www.population.gov.ng/index.php/censuses

Flenley, J. and Bahn, P. (2007). Conflicting views of Easter Island. *Rapa Nui Journal*, 21(1), 11-13.
Geert, H. and Jan, H. G. (1991). *Cultures and organizations: Software of the mind*. New York: McGraw-Hill.
Hawkes, D. (2011). *In brief: A history of sustainable architecture.* Available at: http://www.architecture.com/SustainabilityHub/Designstrategies/Introduction/1-0-5-Inbriefahistoryofsustainablearchitecture.aspx
Hawkes, D. (2012). *Architecture and climate: An environmental history of British architecture, 1600-2000*. London: Routledge.
Hawkes, D. (2013). *The environmental tradition: Studies in the architecture of environment*.Oxford: Taylor & Francis.
Hofstede, G. (1980). Motivation, leadership, and organization: Do American theories apply abroad? *Organizational Dynamics*, 9(1), 42-63. doi:http://dx.doi.org/10.1016/0090-2616(80)90013-3.
Hofstede, G. (1984). Cultural dimensions in management and planning. *Asia Pacific Journal of Management,* 1(2), 81-99. doi:10.1007/BF01733682.
Hunt, T. L. (2007). Rethinking Easter Island's ecological catastrophe. *Journal of Archaeological Science,* 34(3), 485-502.
Husted, B. W. (2005). Culture and ecology: A cross-national study of the determinants of environmental sustainability. *MIR: Management International Review*, 349-371.
Keraminiyage, K. P. (2009). *Achieving high process capability maturity in construction organisations.* A thesis submitted to the Department of the , Built Environment for a doctoral degree, Salford University, Manchester.
Kibert, C. (1993). Construction materials from recycled polymers. . *Proceedings of the Institution of Civil Engineers (ICE) - Structures and Buildings*, 99(4), 455-464.
Kibert, C. J. (2005). *Sustainable construction : Green building design and delivery*. Hoboken, N.J.: Wiley.
Kibert, C. J., Sendzimir, J. and Guy, B. (2000). Construction ecology and metabolism: Natural system analogues for a sustainable built environment. *Construction Management & Economics,* 18(8), 903-916. doi:10.1080/014461900446867.
King, N. (2012). Doing template analysis. In: G. Symons and C. Cassell (eds.).*Qualitative Organizational Research: Core methods and current challenges*, pp.426-450.
Lee, A. (2002). *The development of a project process evaluation (PPE) framework that aims to measure the effectiveness of implementing a new design and construction project process*. A thesis submitted for a doctoral degree, Salford University, Manchester.
Mark, D. (2000). Sustainability and sustainable development. In: D. C. Dunphy (ed.). *Sustainability : The corporate challenge of the 21st century*. London: Allen & Unwin.
McDonough, W. and Braungart, M. (2009). *Cradle to cradle : Remaking the way we make things*. London: Vintage.
Meadows, D. H., Meadows, D. L., Randers, J. and Behrens, W. W. (1972). *The limits to growth : A report for the Club of Rome's project on 'The Predicament of Mankind'*. New York: Potomac Associates.

Mieth, A. and Bork, H.-R. (2010). Humans, climate or introduced rats – which is to blame for the woodland destruction on prehistoric Rapa Nui (Easter Island)? *Journal of Archaeological Science,* 37(2), 417-426.
Morris, A. E. J. (2013). *History of urban form before the industrial revolution*. London: Routledge.
Najam, A. (2005). Developing countries and global environmental governance: From contestation to participation to engagement. *International Environmental Agreements,* 5, 303-321. doi:10.1007/s10784-005-3807-6
.
Nowak, P. O., Steiner, M. and Wiegel, U. (2009). Waste management challenges for the construction industry. *Construction Information Quarterly*, 11(1), 5-11.
Odum, E. P. (1993). *Ecology and our endangered life-support systems* (2nd ed.). Sunderland, Mass.: Sinauer Associates.
Ogunshakin, L. and Olayiwola, L. (1992). The collapse of official housing policy in Nigeria. *Habitat International*, 16(1), 41-53. doi:http://dx.doi.org/10.1016/0197-3975(92)90006-K.
Okafor, C. (2015). Nigeria-China trade volume rises to $23.5bn. *This Day Live*. Available at: http://www.thisdaylive.com/articles/nigeria-china-trade-volume-rises-to-23-5bn/210947/
Olukoju, A. (2004). Nigerian cities in historical perspective. In: T. Falola and S.J.Salm (eds.). *Nigerian Cities*, pp.11-46.
Osmani, M. (2012). Construction waste minimization in the UK: Current pressures for change and approaches. *Procedia - Social and Behavioral Sciences,* 40(0), 37-40. doi:http://dx.doi.org/10.1016/j.sbspro.2012.03.158.
Pacheco-Torgal, F., Tam, V., Labrincha, J., Ding, Y. and De Brito, J. (2013). *Handbook of recycled concrete and demolition waste*. Oxford: Elsevier.
Park, H., Russell, C. and Lee, J. (2007). National culture and environmental sustainability: A cross-national analysis. *Journal of Economics and Finance,* 31(1), 104-121.
Phillips, D. A. (2003). *Nigeria*. Available at: https://www.dawsonera.com/abstract/9781438105253
Phillips, D. A. (2004). *Nigeria*. Philadelphia: Chelsea House.
Raine, S. (2013). *China's African challenges.* London: Routledge.
Republic of Ireland. Department of the Environment (DOE). (2012). *Waste management: The duty of care- a code of practice for Northern Ireland.* Northern Ireland: Department of the Environment. Available at: http://www.doeni.gov.uk/waste_management_duty_of_care_code_of_practice_for_ni.pdf
Royal Institute of Bristish Architects (RIBA).(2009a). *Carbon literacy briefing.* Available at: http://www.architecture.com/Files/RIBAHoldings/PolicyAndInternationalRelations/Policy/Environment/2Carbon_Lit_Briefing.pdf
Royal Institute of Bristish Architects (RIBA). (2009b).

Assessment for low carbon design. *Climate Change Tool Kit 08: Whole Life.*

Available at: http://www.architecture.com/Files/RIBAHoldings/PolicyAndInternationalRelations/Policy/Environment/WholeLifeAssessment.pdf

Royal Institute of Bristish Architects (RIBA). (2009c). *Low carbon standards and assessment methods.* Available at:http://www.architecture.com/Files/RIBAHoldings/PolicyAndInternationalRelations/Policy/Environment/2Low_Carbon_SA_Methods.pdf

Royal Institute of Bristish Architects (RIBA). (2009d). *Principles of low carbon design and refurbishment*. Available at: http://www.architecture.com/Files/RIBAHoldings/PolicyAndInternationalRelations/Policy/Environment/2Principles_LC_Design_Refurb.pdf

Rogers, K. (2011). *Two years under glass:The first biosphere 2 mission.* Available at: http://www.britannica.com/blogs/2011/09/years-glass-biosphere-2-mission/

Sassi, P. (2008). Defining closed-loop material cycle construction. *Building Research & Information*, 36(5), 509-519. doi:10.1080/09613210801994208.

Schneider, D. and Ragossnig, A. (2014). Impacts and limitations of recycling. *Waste Management & Research*, 32(7), 563-564. doi:10.1177/0734242x14541620

Schwerdtfeger, F. W. (1982). *Traditional housing in African cities: A comparative study of houses in Zaria, Ibadan, and Marrakech*: LUP. Chichester: John Wiley and Sons.

United Kingdom (UK). Green Building Council. (2013). *Key statistics*. Available at: http://www.ukgbc.org/content/key-statistics-0

Urquhart, A. W. (1977). *Planned urban landscapes of Northern Nigeria : A case study of Zaria*. Zaria: Ahmadu Bello University Press.

Whitsitt, N. (2003). Islamic-Hausa feminism meets Northern Nigerian romance: The cautious rebellion of Bilkisu Funtuwa. *African Studies Review*, 46(1), 137-153. doi:10.2307/1514984.

Yin, R. K. (1981). The case study crisis: Some answers. *Administrative Science Quarterly*, 26(1), 58-65. doi:10.2307/2392599

Yin, R. K. (2009). *Case study research : Design and methods* (4th ed.). London: Sage.

A CONTINUOUS IMPROVEMENT FRAMEWORK USING IDEF0 FOR POST-CONTRACT COST CONTROL

Temitope OMOTAYO[1] and Udayangani KULATUNGA[2]

[1] Scott Sutherland School of Architecture and the Built Environment, Robert Gordon University, Aberdeen, United Kingdom, AB10 7GJ, Email: t.s.omotayo@rgu.ac.uk
[2]School of the Built Environment, University of Salford, Manchester, United Kingdom, M5 4WT, Email: u.kulatunga@salford.ac.uk

ABSTRACT

Advancements in construction project management have necessitated a comprehensive rethink of construction project processes. Gantt charts and critical path analysis have been produced to create a work breakdown structure which can identify challenges and crucial infrastructure development activities which can have an adverse impact on the project. However, they do not improve the construction process. Integration Definition Language 0 (IDEF0) models present an opportunity for construction project managers to identify essential workflows during construction and improve them. The improvement process is continuous. Hence, kaizen, which is part of lean construction, can be implemented. This study demonstrated the use of IDEF0 in a building construction project in Nigeria where the construction companies have issues with cost, overruns, low competitive advantage and unsatisfied clients. The build up to the challenges identified post-contract cost controlling techniques as an important variable in establishing the challenges above in the construction industry. With the aid of Kendall's coefficient of concordance, the analysis was carried out to determine the techniques which are most important and effective in managing construction costs during the execution phase. Monitoring building material cost was identified to be the most important technique. The recognised significant and effective techniques were used to build a continuous improvement model with accompanied drivers such as the working budget and monitoring of overheads. The output of the findings was presented in an IDEF0 model with some written guidelines. The model designed in this study can be used on construction sites by cost and project managers to reduce and maintain current costs from the working budget through continuous improvement.

Keywords: Cost controlling techniques, continuous improvement, framework, kaizen costing, post-contract

INTRODUCTION

ICAM definition for function modelling (IDEF0) is a process improvement tool

which is usually available on Microsoft Visio. ICAM is an acronym for integrated computer-aided manufacturing (Veis et al., 2009). IDEF0 is similar to a Gantt chart, and network diagram. However, IDEF0 allows professionals to view complex processes from a clearer perspective (Veis et al., 2009). IDEF0 is mainly used for business process re-engineering, production planning and control, integrated product development, just-in-time, and construction process improvement (Mayer et al., 1992; Soung-Hie and Ki-Jin, 2000:, Veis et al., 2009). Basically, IDEF0 is used to organise workflows in a more logical and simplified manner to create a model of activities. This model is embedded in a framework which is generally used to improve the business process. The primary components of IDEF0 are the input control, mechanism, function and output (Hirao et al., 2008, Imran et al., 2010). IDEF0 is used for process improvement which is related to continuous improvement of activities. There have been challenges in the construction industry. Major challenges include stiff competition for project opportunities in Nigeria, cost and time overruns, operation management problems and poor production quality. IDEF0 can be used to mitigate the aforementioned challenges by identifying the input, control mechanism and final output of the work package. The IDEF0 process is illustrated below.

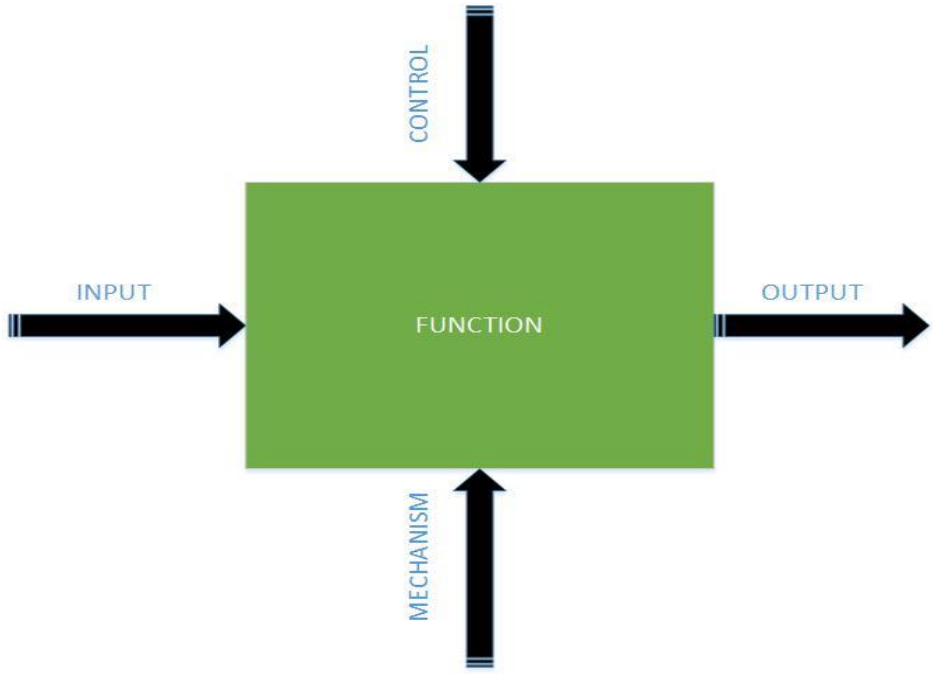

Figure 1: The IDEF0 process (Adapted from Soung-Hie and Ki-Jin, 2000)

According to Soung-Hie and Ki-Jin (2000), in the IDEF0 illustration above the function is the activity which will be carried out; the inputs are factors which the events may alter; the control is external constraints which may impede the success of the construction operations while the mechanism is the tool or means to fulfil the

action. The output is the result of the activity. To represent the framework in this study, the IDEF0 is decomposed into various activity groups. The design of IDEF0 for a process or activity is based on an existing process which has to be improved. In this study, it will relate to the post-contract cost-controlling techniques in Nigeria. The aim of this study was to demonstrate the usefulness of IDEF0 as a continuous improvement tool in post-contract cost control. Therefore, the performance of post-contract cost controlling techniques used in Nigeria was evaluated.

Post-contract cost controlling procedure in Nigeria

Post-contract cost control starts from the initial budget that has been planned. An interim valuation follows this at the construction stage. At the construction stage, the contractor cash flow is prepared to monitor the project finances to ensure profitability (Sanni and Hashim, 2013). Another technique used in monitoring construction cost during execution is earned value analysis (Hunter et al., 2014). New techniques involving an intranet-based cost controlling system have also been proposed by Abudayyeh et al. (2001). Measuring work on the site may also include methods such as cost ratio calculation, incremental milestone, units completed and weighted units (CII, 2000). Managing cost during construction involves making the right decisions at the right time and ensuring the cost of each activity does not go beyond the projected cost.

Cost control of any project starts from inception and ends at the completion with the issuing of final certificates (Ashworth and Perera, 2015). According to Ashworth and Perera (2015), the post-contract stage of a project begins from when the contract is signed to the final account and certificate. The process of controlling cost in the post-contract stage is detailed as:

1) Interim valuations and payment certificate,
2) Cash flow and forecasts through budgetary control,
3) Financial statements showing the current and expected final cost for the project, and
4) Final account, the agreement of final certificate and the settlement of claims. (Ashworth and Perera, 2015).

The choice of a method of controlling the cost of a project during the post-contract stage depends on the contractor's selection method; the price determination method for the tender and final account; client or contractor control; and the duties of the quantity surveyor in managing the budget and account (Ashworth and Perera, 2015). The four main stages highlighted above may vary depending on the type of construction project. Every construction project and the teams involved in any construction project are unique. Therefore, the method used in controlling cost during a project will also be exclusive. The various techniques

identified according to the relevant literature are explained in Table 1 that follows.

Table 1: Post-contract cost control techniques

S/N	Post-contract cost controlling techniques	Reference
1	Cash flow	Ashworth and Perera, 2015; Sanni and Durodola, 2012; Sanni and Hashim, 2013
2	Taking corrective action	Ashworth and Perera, 2015; Sanni and Durodola, 2012
3	Monitoring overheads	Ashworth and Perera, 2015; Sanni and Durodola, 2012
4	Monitoring labour cost	Ashworth and Perera, 2015; Sanni and Durodola, 2012
5	Monitoring material cost	Ashworth and Perera, 2015; Sanni and Durodola, 2012
6	Monitoring equipment cost	Ashworth and Perera, 2015; Sanni and Durodola, 2012
7	Managing variations	Olawale and Sun, 2010; Ashworth and Perera, 2015; Sanni and Durodola, 2012
8	Intranet based cost controlling	Abudayyeh et al., 2001
9	Unit rate	Olawale and Sun, 2010; Ashworth and Perera, 2015
10	Interim valuations	Ashworth and Perera, 2015
11	Incremental milestone	CII, 2000; Leu and Lin, 2008;
12	Site meeting and post-project reviews	Ankur and Pathak, 2014; Leu and Lin, 2008; Czarnigowska,

		2008.
13	Identifying indicators of cost overruns	Ashworth and Perera, 2015; Olawale and Sun, 2010; Sanni and Durodola, 2012
14	Summarising profit and loss	Sanni and Durodola, 2012; Ashworth and Perera, 2015.
15	Site meetings	Puvanasvaran et al., 2010; Berger 1997; Chukwubuikem et al., 2013
16	Cost ratio	Sanni and Durodola, 2012
17	Cost forecasting	Sanni and Durodola, 2012; Czarnigowska, 2008
18	Using established budget and targets	Sanni and Durodola, 2012; Ashworth and Perera, 2015

(Source: Authors)

Improving post-contract cost controlling techniques using kaizen costing

The term 'continuous improvement' or *kaizen* has become common in many organisations in the world. Contrary to the belief of many authors that kaizen started with the Toyota production system (TPS) along with lean production, Shang and Pheng (2013) argue that kaizen started in the United States when the government started the "training within industry" programme during the World War II, before it was brought to Japan. Continuous improvement is not only relevant to performance management but also to production management in both large corporations and small- and medium-scale enterprises (SMEs). Lean thinking and continuous improvement have been harnessed by many organisations as tools for improved performances in all divisions. Koskela and Ballard (2012) argued that failure to leverage the concept of product in management has led to challenges in the field of management science for half a century. The use of production techniques such as lean production in construction has been a major subject of discussion in academia. The concept of lean production has significantly improved the cost, quality, client satisfaction and construction project delivery (Sacks, Koskela, Dave and Owen, 2010). Studies in the area of lean production involved case studies of various industries other than the construction sector. Therefore the benefits highlighted by

Sacks et al. (2010) have cut across these sectors.

In this investigation, the post-contract cost control process will be improved using the Plan-Do-Check Act (PDCA) principle of kaizen. According to Puvanasvaran et al. (2010), another approach to kaizen costing involves the PDCA process. This process includes the following seven stages:

1) Defining the plot area or section which requires improvement;
2) Identifying the losses from non-value added activities which are documented in a template;
3) Scheduling the activities to be reviewed for solutions;
4) Organising the project team to brainstorm possible solutions;
5) Implementing the solutions involving PDCA. PDCA also includes research, data collection and analysis;
6) Confirming the effectiveness by looking at before and after approach, and
7) Following up with the implemented plan requiring a checklist sheet, employees, the top management.

These steps will be applied to the process involved in techniques used to improve the identified post-contract cost controlling techniques in Table 1. Hence, the methodology for process follows below.

1. RESEARCH METHODOLOGY

A survey strategy was used to collect data from eighty-three (83) construction companies in Lagos, Nigeria. The companies responded with one hundred and thirty-five questionnaires out of two hundred and fifty (250) questionnaires which had been distributed to the quantity surveyors and project managers in these small- and medium-scale construction companies (SMSCCs). The Kendall W test was used to rank these post-contract cost-controlling techniques afterwards. The Kendall W test is a non-parametric test. According to Legendre (2005), Kendall's coefficient of concordance (W) is a measure of the pact among several (p) judges who are assessing a given set of n objects. This test evaluated the degree of similarity between two sets of ranks for the same round of variables. This level compares each variable as a pair to rank the most important variable. Mehta and Patel (2012) noted that the Kendal W test is a scaled Friedman's test with the formula:

$$W = \frac{Tf}{N(K-1)} \qquad (1)$$

The test produces the p values which are the asymptotic p-value. If the p-value is less than 0.05, this is acceptable. Also, Kendall's coefficient of concordance (W) should also be less than 0.05 for fair values (Mehta and Patel, 2012). The ranking

produced by Kendall's W coefficient of concordance is a form of measure of association (Mehta and Patel, 2012). Legendre (2005) further noted that Kendall's W is the measure of the degree to which the *K* applicants agree with the *N* judge. The N measures the level of effectiveness or importance of the various post-contract cost-controlling techniques which are used by small- and medium-scale construction companies in Lagos, Nigeria.

The most effective techniques used in post-contract cost control are the techniques which lead to successful implementation. The techniques that produce the desired results when required are the most useful. Therefore, these techniques have more impact on the entire construction project during the execution phase. The most important post-contract cost controlling technique is the one which cannot be left out during the post-contract cost control activities. These techniques are processes which the cost or project manager needs to adopt during construction to ensure that the project stays within budget. It is imperative to evaluate the useful and relevant post-contract cost controlling techniques because they are used to address the problems facing traditional post-contract cost control in small- and medium-scale construction companies in Lagos, Nigeria. The evaluations are required to understand implementable strategies for kaizen and kaizen costing in these types of organisations, based on the respondents' perception of these techniques.

The Kendall coefficient of concordance (W) was applied to evaluate the level of agreement between the various post-contract cost controlling techniques and the respondents' Likert scale ranking. The purpose of this was to assess the most efficient post-contract cost-controlling techniques and also to determine what techniques small- and medium-scale construction organisations in Lagos are using. The results of this test assisted in comparing the present level of the post-contract cost control system used in practice in Nigeria with what is used in other developed countries such as the United Kingdom, Japan and the United States of America. The purpose of the effectiveness test is to provide a clear understanding of the requirements for a framework necessary for the implementation of kaizen costing in small- and medium- scale construction companies in Nigeria.

Effectiveness of post-contract cost controlling techniques

From the chart below, the technique which involves monitoring material cost ranks the highest with a value of 11.33; and interim valuations are perceived to be the second most effective with a value of 10.98. The use of an established working budget such as cost information from the bill of quantities, preliminary items of work and material schedule ranks third with a value of 10.62. Taking corrective action and monitoring equipment cost have a value of 10.61 and 10.41 respectively. They ranked fourth and fifth. The least most effective post-contract cost control technique is cash flows. This has a value of 7.85. Other less effective techniques are variation management, cost forecasting, profit and loss summary, and cost ratio, with values of

7.86, 8.09, 8.4 and 8.4 respectively.

The degree of agreement of this ranking of Kendall's W is given as 0.05. Kendall's W value is always between 0 and 1. 0 indicating that there is no agreement between the respondents, while 1 indicates a perfect agreement (Pallant, 2009). The respondents' positions on each of the post-contract cost controlling techniques are not in complete agreement with each other. The respondents have divergent opinions concerning this question as indicated by the result. Nonetheless, there is a significant association between the post-contract cost controlling techniques and the respondents.

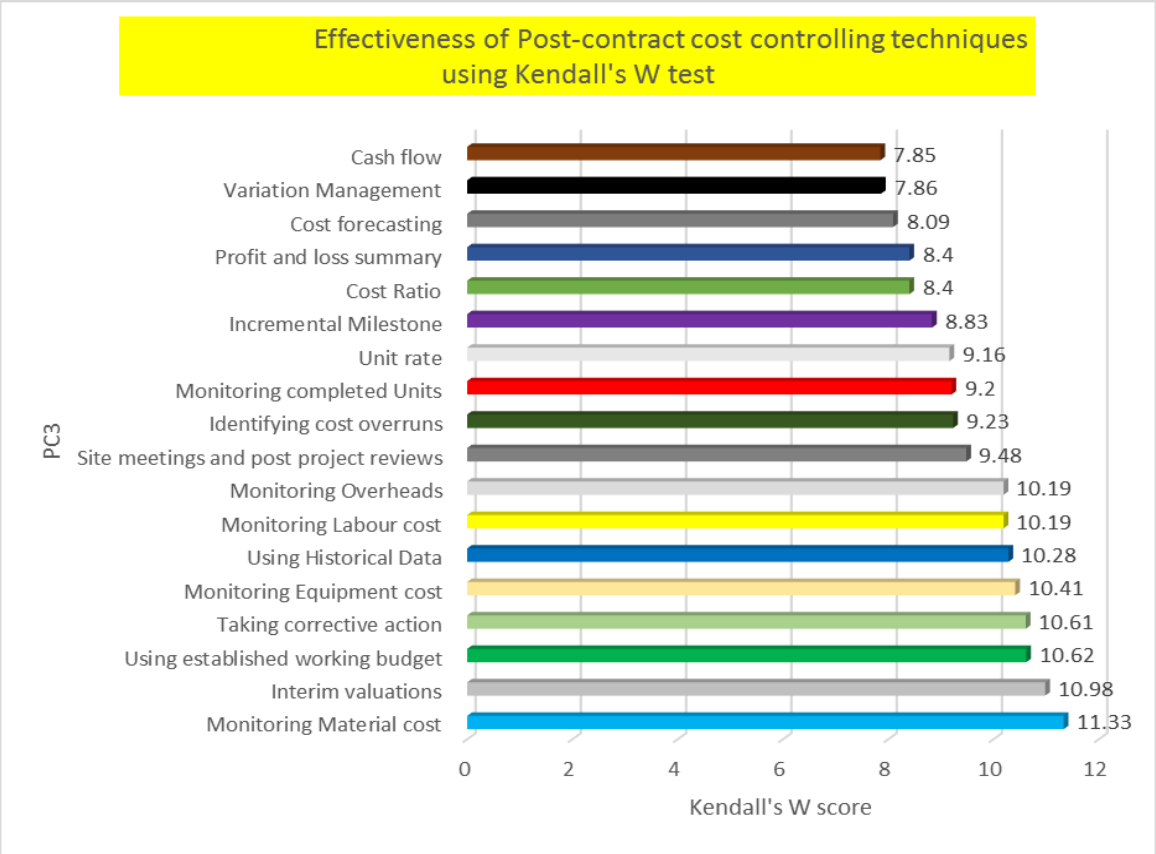

Figure 2: Effectiveness of post-contract cost control

The respondents prioritised these post-contract cost control procedures as listed above in descending order. The asymptotic significance value was also less than 0.05. Therefore, there is a high significant association between the respondents and the techniques.

Table 2: Kendall's W test for effectiveness of post-contract cost controlling techniques

Criteria	Figures
N	135
Kendall's W	0.050
Chi-square	113.973
Df	17
Asymp. Sig	0.000

(Source: Authors)

Kendall's coefficient of concordance for the most important post-contract cost controlling techniques

The Kendall's coefficient of concordance test explained in section 2.0 would also be used for this analysis. Kendall's coefficient of concordance also ranks the various techniques in descending order. Monitoring material cost had a value of 11.44. Monitoring labour cost had a value of 11.26 and is ranked second, while profit and loss summary, using established the working budget, site meeting and post project reviews were ranked third, fourth and fifth with values of 11.13, 11.03 and 10.43 respectively. The least most important technique is variation management with a Kendall W score of 6.88. The cost ratio is second least most important with a Kendall W score of 8.01. Other techniques ranked by the respondents are monitoring overheads, cash flow and using historical data. These techniques have values of 8.31, 8.37, and 8.62 respectively.

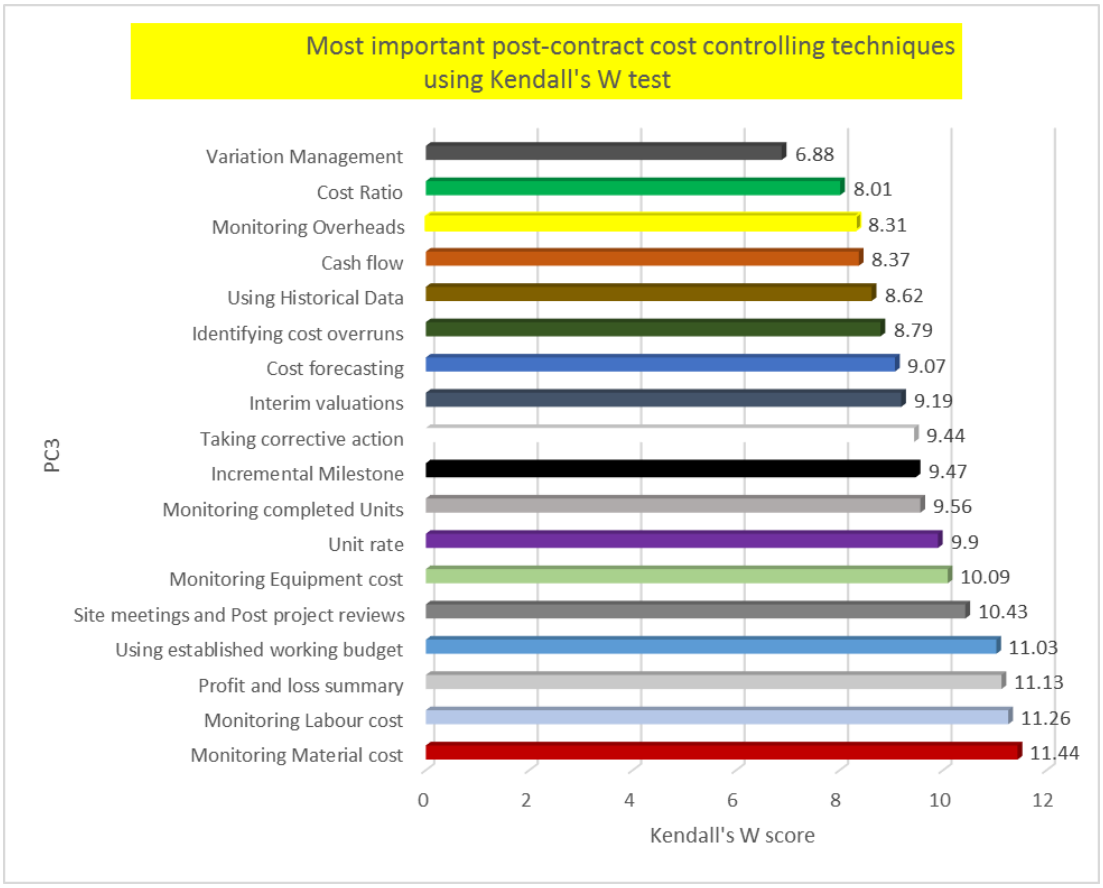

Figure 3. Important post-contract cost control techniques

The Kendall W score of 0.043 shows an insignificant level of agreement for the most important post-contract cost controlling techniques and the respondents' rankings on the Likert scale.

Table 3: Kendall's W test for important post-contract cost control techniques

Criteria	Figures
N	135
Kendall's W	0.043
Chi-square	145.451
Df	17
Asymp. Sig	0.000

(Source: Authors)

The asymptotic significance value is also less than 0.05, thereby reflecting the importance of the respondents and the techniques.

DEVELOPING THE IDEF0 MODEL

Quantitative analysis was carried out on the types of PC3 techniques in Nigeria with the aid of Kendall's coefficient of concordance test to rank the PC3 and also to evaluate the level of agreement among the respondents. This was analysed in figures 2 and 3. The evaluation aspect of the objective was carried out using Kendall's coefficient of concordance. The Kendall's W test ranked the various post-contract cost control techniques, and also evaluated the most effective and most important techniques. The most effective and most valuable techniques were identified as monitoring material cost. Cash flow was ranked lowest as the least efficient technique. Variation management is considered to be the least important technique. Using a working budget during the construction process was ranked second as an effective technique. The bill of quantities, according to Rad (2002) and Oyedele (2015), has inaccuracies with the use of measurement CAD software. Once there is a problem with the design, there will be inaccurate estimates.

Ashworth and Perera (2015) highlighted the first major steps of post-contract cost control as being monitoring and interim valuations, cash flow, monthly statements, and issuing final certificates. The techniques were not highlighted. Monitoring cost involves performance metrics (Oyedele, 2015), and cost controlling activities depend on whether the processes on the site are within budget. Some of these processes include the site visit, meetings, monthly cash flow calculation and payment of contractors. Some authors argue that one cannot control cost but only monitor what is going on during construction and then take corrective action. The debate between cost monitoring and control activities may only be because of the semantics. For this investigation, cost control is the art of reducing unnecessary expenses during construction, while budget monitoring is the process of ensuring the project is within the established working budget, hence the bill of quantities.

Kaizen costing for post-contract cost control in the IDEF0 framework

Kaizen costing pertains to reducing expenses during construction and maintaining quality for maximum profit and client satisfaction (MÍkva et al., 2016; Knechtges and Decker, 2014; Radharamanan et al., 1996). Therefore, the controlling activities on a site based on the techniques should include the principles of plan-do-check-act. The plan-do-check-act will require one of the professionals to be actively involved in the PDCA process. The framework for post-contract cost control will require monitoring activities as interim valuations as a primary approach for incrementally reducing the expenses on site. The IDEF0 model will be used for this process.

IDEF0 process for post-contract cost control process

The IDEF0 is a modelling technique for process improvement. This model has been explained earlier. The model is usually carried out to reflect the normal process and the model that has been improved. In this study, the improved process has been developed for the framework. This is displayed in Figure 4. After the award of contract and the mobilisation fee has been paid to the contractors, the construction process commences. This process makes use of the working budget. The overall aim of the contractor is to make a profit and provide the best quality product on time to a satisfied client.

The IDEF0 process in figure 3 starts with cost monitoring and control activities using a well set out standard for construction. Interim valuations are conducted at intervals based on the Gantt charts or programme of works. The units completed based on the tender sums are sent to the client's quantity surveyor for interim payments. This process has to consider the overhead expenses which are monitored. Some of the overhead expenses include the water, access roads, electricity, sanitation, office overheads such as stationery, tables, chairs and other necessities associated with the preliminary items of work. The elimination of unnecessary activities and waste in the preliminary item of works is essential. PDCA is implemented at this stage. An employee may be appointed as a supervisor to monitor this process for timeous corrections. Taking corrective action is imperative to the implementation of kaizen costing during post-contract cost control.

The stage payments will be entered into the cash flow for calculations. This is connected to the monitoring activities for plant, labour and materials. The contractor quantity surveyor has to reduce and maintain the subcontractors' quotations and therefore negotiation skills may be required at this stage. A consultation process is necessary for labour rates and plant hire. The PDCA also comes into the negotiation skills to identify the best activities for reducing the cost of labour, material and plant. Reducing the cost of labour may not be ideal in developing countries, but kaizen costing may ensure that the labour cost is maintained and the right workers are paid for the right activities. The monitoring of plant, equipment and labour is crucial for kaizen costing implementation. Overhead costs relating to material, labour and plant

may be reduced continually for the attainment of a suitable final construction cost. This process is repeated during each stage of interim valuation and cash flow.

Variation management is another aspect where the contractor quantity surveyor may lay claims to change the design. Variation management and financial constraints on the part of the client may lead to disputes, cost overruns and project delays. In Nigeria, variations and changes have caused many projects to be abandoned. Therefore, the quantity surveyor and project manager (who may be an architect) need to work together to effect a speedy resolution. The PDCA process can be adopted for the elimination of unnecessary activities, products, and waste when conducting variation management.

The quantity surveyor will then prepare the final financial certificate, which is a statement of the overall construction cost. In many projects, the budget of the project is not always equal to the final tender sum. There may be a slight overrun on the budget. Nonetheless, most projects involving kaizen costing during the production phase have always experienced increased profit, project completion on time, quality delivery, satisfied client, improved competitive advantage and project performance.

CONCLUSION

The findings showed that monitoring the cost of material is the most effective and important technique on site. Monitoring the cost of materials has to do with inflation, transportation of material to site, purchase order, and quotation from supplier and sub-contractors. The entire concept of monitoring is paramount to the contractor because this is where the profit lies. Monitoring of labour rates on the site is also essential. The prices of materials and labour may vary from state to state in Nigeria. However, this study was based on Lagos, Nigeria where the prices are fairly stable. The cost of building materials for building construction may fluctuate during the duration of the project. Building material supply is also connected to other critical success factors, namely construction business and ethics, which may be investigated for further studies. Many fraudulent practices take place during development activities in Nigeria, and these include bribery, the kickback of funds and the inflation of prices, which affects the quality of cost information. Corruption in the Nigerian construction industry is a major factor that may hinder the effectiveness of any approach to cost management.

Another useful technique is using a working budget. The working budget is the bill of quantities, and it is always riddled with errors right from the planning phase. These errors are carried over to the execution stage. Nonetheless, a working budget is very effective if the unit rates from the budget and quantities are meticulously monitored during the planning stage. The management of variation and cash flow calculation were added to the framework but were ranked very low in the analysis. Many factors might be responsible for this, but it requires further investigation. The changes in post-contract cost control have to evolve over time. The change can be

carried out using kaizen. Hence, kaizen which is a form of continuous improvement, may exist in small and medium-sized construction companies in Nigeria.

IDEF0 has a way of identifying the primary processes which may assist the quantity surveyor or project manager to improve the entire construction process. The time it takes for the improvement will not affect the whole construction project because the identified problems are resolved immediately. However, further research could look at the cost implications of having this type of framework for PC3.

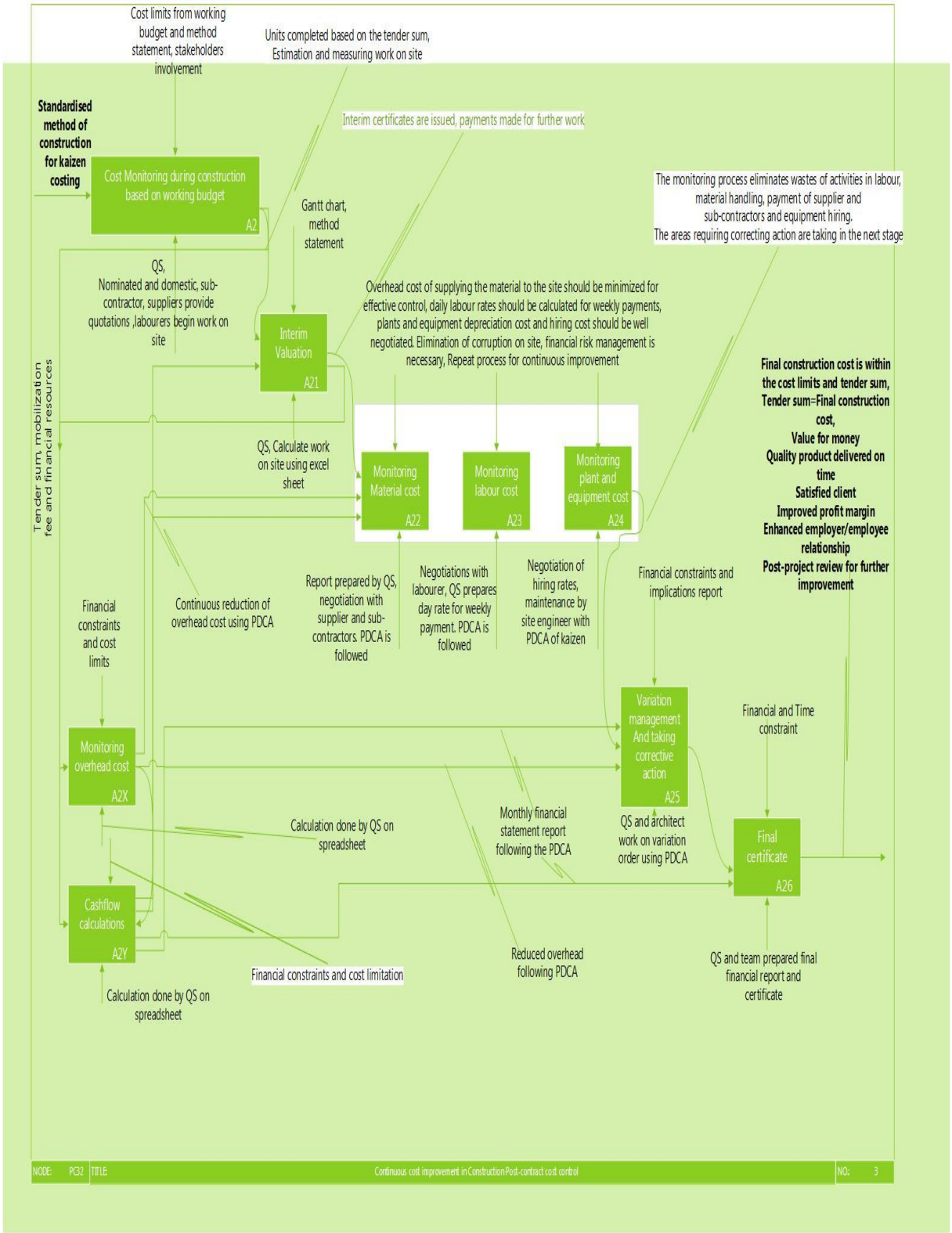

Figure 4. IDEF0 process for post-contract cost control of a hypothetical building construction

REFERENCES

Ashworth, A. and Perera, S. (2015). *Cost studies of buildings* (5th ed.). London: Routledge.

Abudayyeh, O., Temel, B., Al-Tabtabai, H. and Hurley, B. (2001). The intranet-based cost control system. *Advances in Engineering Software,* 32**,** 87-94.

Ankur, K.. K. and Pathak, R.K.D. (2014). Earned value analysis of construction project at Rashtriya Sanskrit Sansthan, Bhopal. *International Journal of Innovative Research in Science, Engineering and Technology,* 3**,** 11350-11355.

The Construction Industry Institute (CII). (2000). *Project control for construction*. University of Texas, Austin, USA: The Construction Industry Institute.

Czarnigowska, A. (2008). Earned value method as a tool for project control. *Budownictwo i Architektura,* 3**,** 15-32.

Hirao, M., Sugiyama, H., Fischer, U. and Hungerbühler, K. (2008). IDEF0 activity modeling for integrated process design considering environmental, health and safety (EHS) aspect. In J. Bax (ed,). e *Proceedings of the 18th European Symposium on Computer Aided Process Engineering* Lyon Cedex, France.

Hunter, H., Fitzgerald, R. and Barlow, D. (2014). Improved cost monitoring and control through the earned value management system. *Acta Astronautica,* 93**,** 497-500.

Imran, S., Foping, F., Feehan, J. and Dokas, I.M. (2010). Domain specific modeling language for early warning system: Using IDEF0 for domain analysis. *IJCSI International Journal of Computer Science and Information Security,* 7**,** 10-17.

Knechtges, P. and Decker, M.C. (2014). Application of kaizen methodology to foster departmental engagement in quality improvement. *Journal of the American College of Radiology*, 11(12, Part A), 1126–1130. Available at: http://www.sciencedirect.com/science/article/pii/S1546144014005055.

Legendre, P. (2005). Species associations: The Kendall coefficient of concordance revisited. *Journal of Agricultural, Biological, and Environmental Statistics,* 10**,** 226-245.

Lin, B., Collins, J. and Su, R. K. (2001). Supply chain costing: An activity-based perspective. *International Journal of Physical Distribution & Logistics Management,* 31**,** 702-713.

Mayer, R. J., Painter, M. K. and Dewitte, P. S. (1992). *IDEF family of methods for concurrent engineering and business re-engineering applications.* Washington, DC:Knowledge Based Systems, Inc.

Mehta, C. R. and Patel, N. R. (2012). *IBM SPSS Exact Tests.* Cambridge, MA:IBM Corporation.

MÍkva, M., Prajova, V., Yakimovich, B., Korshunov, A. and Tyurin, I. (2016). Standardization – one of the tools of continuous improvement. *Procedia Engineering*, 149, 329–332. Available at: http://www.sciencedirect.com/science/article/pii/S1877705816311845.

Olawale, Y. and Sun, M. (2010). Cost and time control of construction projects: Inhibiting factors and mitigating measures in practice. *Construction Management and Economics,* 28**,** 509 – 526.

Pallant, J. (2009). *SPSS survival manual: A step by step guide to data analysis using SPSS for windows* (3rd ed.).. Buckingham, Philadelphia: Open University Press.

Puvanasvaran, A. P., Kerk, S. T. and Ismail, A. R. (2010). A case study of kaizen implemention in SMI. *Proceedings of the National Conference in Mechanical Engineering Research and Postgraduate Studies*. 3-4 December. Universiti Malaysia Pahang, Pekan, Kuantan, Malaysia., pp. 374-392.

Radharamanan, R., Godoy, L.P. and Watanabe, K.I., (1996). Quality and productivity improvement in a custom-made furniture industry using kaizen. *Computers & Industrial Engineering*, 31(1–2), 471–474. Available at: http://www.sciencedirect.com/science/article/pii/0360835296001775.

Sanni, A. O. and Durodola, O. D. (2012). Assessment of contractors' cost control practices in Metropolitan Lagos. In*:* S. Laryea, S.A. Agyepong, R. Leiringer and W. Hughes (eds.). *Proceedings of the 4th West Africa Built Environment Research (WABER) Conference.* 24-26 July. Abuja, Nigeria.

Sanni, A. O. and Hashim, M. (2013). Assesing the challenges of cost control practices in the Nigerian construction industry. *Interdisciplinary Journal of Contemporary Research in Business* 4**,** 366-374.

Shang, G. and Pheng, L. S. (2013). Understanding the application of kaizen methods in construction firms in China. *Journal of Technology Management in China,* 8**,** 18-33.

Soung-hie, K. and Ki-jin, J. (2000). Designing performance analysis and IDEF0 for enterprise modelling in BPR. *International Journal of Production Economics,* 7**,** 121-133.

Veis, Š., Predrag, D., Ratomir, J. and Dragana, L. (2009). Functional and information modelling of production using IDEF methods. *Journal of Mechanical Engineering,* 55**,** 131-140.

MODELLING A CONCEPTUAL FRAMEWORK OF TECHNOLOGY TRANSFER PROCESS IN CONSTRUCTION PROJECTS: AN EMPIRICAL APPROACH

De-Graft OWUSU-MANU[1], Erika Anneli PÄRN[2], Maxwell Fordjour ANTWI-AFARI[3], and David John EDWARDS[4]

[1]Senior lecturer, Department of Building Technology, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana, Email: d.owusumanu@gmail.com
[2]Lecturer, Faculty of Technology Environment and Engineering, Birmingham City University, Birmingham, UK, Email: erika.parn@bcu.ac.uk
[3]Graduate assistant, Department of Building Technology, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana, Email: maxbeez279@yahoo.com
[4]Professor of Plant and Machinery Management, Faculty of Technology Environment and Engineering, Birmingham City University, Birmingham, UK, Email: david.edwards@bcu.ac.uk

ABSTRACT
Technology transfer (TT) is crucial to social infrastructure and economic development in developing countries (DCs). In Ghana's construction sector, foreign firms provide an invaluable source of innovation and technological advancement for local contractors. However, TT models published in existing literature are rarely applicable to the construction industry in DCs. This paper therefore presents a conceptual framework of the TT process as a tool for measuring construction performance. Utilising the results from a questionnaire survey of Ghanaian construction industry professionals, eight different perspectives on TT were formulated using exploratory factor analysis. These perspectives represent the enablers and outcomes of the TT process, namely transferor and transferee characteristics, knowledge advancement, the transfer environment, government influence, the learning environment, project performance, communication, and relationship building and absorptive capability. The research outcomes provide useful guidance to local and international funding agencies, governments of developing or newly industrialised countries, and construction firms that seek to effectively evaluate the success (or otherwise) of the TT process. Future research should seek to validate the research findings presented, and to expand the work to include other DCs.

Keywords: Conceptual framework, Ghanaian government, construction, technology transfer

INTRODUCTION
Technology transfer (TT) has been defined as the movement of knowledge and technology from one individual or firm to another (Gibson and Smilor, 1991). In a broader sense, TT encompasses know-how about the transformation of operational technologies and processes, material technologies, and knowledge technologies (Wilson, 1986). TT provides a powerful source of innovation for construction firms that transform and complement current technologies so as to enhance business performance (Nonaka and Takeuchi, 1995). Consequently, TT is an invaluable stimulus for industrialisation and economic growth in developing countries (DCs) (Ganesan and Kelsey, 2006). Many developing and newly industrialised countries lack core technical and

management capabilities to undertake complex infrastructure projects. To more rapidly develop their infrastructure, economies, and living standards, DCs must embrace TT initiatives in the construction and allied industries. However, these initiatives have not immediately translated into enhanced capabilities and competitiveness with firms in the host countries, resulting in continued reliance on foreign competition. In recent decades, TT research has focused mainly on the business and manufacturing sectors (Malik, 2002; Lin and Berg, 2001). Some of these empirical and qualitative studies have produced frameworks or models of the TT process. Yet these models lack robust empirical data analysis, and none of them have linked TT process enablers to identifiable outcomes. Furthermore, existing models cannot be adopted to comprehensively explain interactions between TT process enablers and outcome factors in a construction context. Neither can existing models and frameworks link the TT process with its associated risk and success factors during TT operations (Lewis, 1998; Moxon and Lewis, 1998). To improve the rates of TT process in DCs, this study aims to develop a more comprehensive TT framework that includes factors to quantify causal relationships between transferor and transferee firms. Factors that impact upon TT performance ultimately impinge upon the degree of value added to the local construction sector. According to San (2004), this is especially true in construction firms in DCs, where it was assumed that more rapid improvement in their management and technical capabilities could be achieved through TT initiatives with foreign firms. These measurement indicators of the TT process may be broadly defined as enablers, and they include the transfer environment, the learning environment, transferor and transferee characteristics, government influence, communication, and relationship building and absorptive capability. The performance of, and interaction between, these enablers can influence the degree of value added to the host construction sector, in areas such as knowledge advancement and project performance. The developed conceptual framework of the TT process presented in this paper illustrates the interactions between TT enablers and outcome factors.

CONCEPTUAL BACKGROUND OF TECHNOLOGY AND TECHNOLOGY TRANSFER

According to Kumar et al. (1999), "technology" consists of two primary components: (i) a physical component, which includes products, equipment, techniques, and processes, and (ii) an information component, which includes know-how about management, marketing, production, quality control, reliability, skilled labour, and functional areas. In a construction context, Tatum (1988) refers to construction technology as the combination of construction methods, construction resources, work tasks, and project influences that define the manner of performing a construction operation. As an extension in terminologies, TT has been characterised in various ways, depending on the particular discipline and the purpose of the research (Bozeman, 2000). Gibson and Smilor (1991) opined that TT is often a chaotic, disorderly process involving groups and individuals who may hold different views about the value of TT (Smith and Alexander, 1988). Most authors concur that TT is a complex process that needs time to evolve (Agmon and Glinow, 1991). TT involves a two-way process, which can succeed only when both the donor and the recipient work together to decide what needs to be transferred and implemented (Sridharan, 1994). Moavenzadeh and Hagopian (1984) suggested that involvement of foreign contractors is a key requirement for development of the local construction industry, and they also reported that local contractors progressively enhance their capability by working with foreign contractors, until they can ultimately offer their own services. In the Singaporean construction industry, it is evident that local contractors' capacity and ability have been enhanced through their involvement with foreign firms (Lam, 1997). Such transfers can be successful when the

transferee can effectively utilise the technologies transferred and ultimately assimilate them (Ramanathan, 1994). The transfer process may involve physical assets, know-how, and technical knowledge (Bozeman, 2000). As such, the TT process may be confined to relocation and exchange of personnel (Osman-Gani, 1999), or transfer of a specific set of capabilities (Lundquist, 2003).

Towards understanding technology transfer in the construction industry

Technology capabilities are crucial for the development of competitive advantage (Baerz et al., 2010). TT is a potentially powerful source of innovation that can provide construction firms with new technologies, which can appropriately transform and complement current technologies, so as to realise and sustain improved performance (Sexton et al., 1999). TT represents the movement of knowledge and technology via some channel, from one individual or firm to another (Gibson and Smilor, 1991). According to Sexton and Barrett (2004), firms need to understand and manage TT activity, so as to ensure consistent success. Diffusion of innovative technologies in the market is usually complex, and the degree of success varies; the effects of diffused innovative technologies opportunities remain underutilised, and diffusion of innovative technologies thus appears to be slow (Van Egmond and Erkelens, 2007). Forming of joint ventures between local and foreign contractors has been recommended by Henriod (1984), and such integration on construction projects can facilitate transfer of construction technology (Ganesan and Kelsey, 2006; Kumaraswamy, 2006; Sexton and Barrett, 2004). According to Simkoko (1989), the TT process in industrial projects differs from that in construction projects; however, both sectors undergo more or less similar phases in realising the process. Evidence of similarities in life cycles is observed in the following construction project phases: conceptualisation (conception, feasibility studies, and inception), implementation (design, engineering, and construction), and operation, or utilisation. During the construction delivery process, capacities and capabilities are provided concurrently, in the sense that construction techniques are employed in project execution, while know-how, managerial skills, and experience act as necessary inputs on the construction techniques. Thus, integration of both local and foreign technological/managerial capabilities in the project delivery process can facilitate transfer of technological capabilities to DCs (Stewart and Waroonkun, 2007).

A critical review of existing models

Various researchers have studied the TT process and international TT models in mainly the business and the manufacturing sectors (Malik, 2002; Lin and Berg, 2001; Simkoko, 1992). A comprehensive TT model that links TT enablers and outcome factors to construction projects in DCs has not yet been developed (Lin and Berg, 2001). From the existing literature, five TT models were examined that could provide perspectives into conceptualising a TT model for the construction sector in Ghana. These models are the Value-Added Model, the Knowledge Transfer Model, the Extended TT Project Life Cycle Model, the Technology Acquisition Model, and the Comparative Marketing Model (Wang et al., 2004; Saad et al., 2002; Calantone et al., 1990).

The Value-Added (VA) Model

Developed by Waroonkun and Stewart (2008), the VA Model attempts to improve the rate of TT in DCs. The transferee refers to Thai architectural, engineering and construction (AEC) firms, and the transferor refers to foreign AEC firms working with Thai firms to procure projects.

Transferor firms had origins in developed nations, such as the United States, Japan, Germany, the United Kingdom, and Australia. The model sought to denote all significant factors that influence the effectiveness of the TT process and the resulting value added. The classification of variables resulted in five definable factors (constructs), namely (i) the transfer environment, (ii) the learning environment, (iii) transferee characteristics, (iv) transferor characteristics, and (v) the TT value added. The structure of the model and the links between the constructs were based on experimental analysis, and they required testing to confirm their appropriateness and validity.

The Knowledge Transfer (KT) Model

The KT Model developed by Wang et al. (2004) sought to better understand the transfer of knowledge from a multinational company to a subsidiary. Semi-structured interviews with 62 multinational companies operating in China provided an analysis data set that identified two stages in the transfer process. Stage 1 focused on the parent company's contribution of knowledge (i.e. capacity and willingness to transfer), while stage 2 focused on the subsidiary company's acquisition of knowledge (i.e. capacity and intent to learn). The inherent weakness of the model is that it is based on case studies of multinational companies that are generalised to theoretical propositions, and not to the general population.

The Extended TT Project Life Cycle (ETT-PLC) Model

Saad et al. (2002) proposed the Extended TT Project Life Cycle (ETT-PLC) Model, which was used to analyse the TT process in Algeria, utilising two case studies based on two integrated mechanisms of TT used between 1965 and 1990, namely turnkey and product-in-hand. The model specifically considered the contractual arrangements that govern TT projects, but it assumed that the procurement and acquisition of hardware, software, and knowledge are relevant to specific industrial and national cases. A complex range of issues associated with the influence of multiple stakeholders on the TT process were identified. However, the ETT-PLC Model concluded that project success can be classified into four categories: (i) how effectively the project meets both the budget and the schedule, (ii) customer impact or satisfaction, (iii) business or direct success, and (iv) future potential.

The Technology Acquisition (TA) Model

The TA Model developed by Simkoko (1992) focused on TT in the construction industry of DCs. The research by Simkoko (1992) was based on case studies of 12 construction projects in DCs in Africa, South America, and Asia undertaken during 1987 and 1988. The objective was to examine the impact of TT programmes and other internal and external environmental factors on construction project performance. Seven factors that impacted upon the construction project delivery process were (i) the project delivery system, (ii) project management teams, (iii) transfer programmes, (iv) client characteristics, (v) project characteristics, (vi) design and construction technologies, and (vii) project performance. This research represents the only available international TT model tailored for the construction sector. However, the research was limited to development of technological and management practices in the local industry, and it failed to model the TT enabling process. Nevertheless, the model offers some insight into possible enablers and outcome factors that impact upon TT in construction projects.

The Comparative Marketing (CM) Model

Calantone et al. (1990) developed the CM Model for international TT based on concepts formulated by Jean Boddewyn's comparative marketing research (Boddewyn, 1966, 1981). The CM Model presents a system made up of five elements, namely (i) environment, (ii) actors, (iii) structure, (iv) process, and (v) functions. The model is extremely complex in design and has not been empirically verified through a robust statistical analysis. Furthermore, while the model includes a number of factors that could be adapted for utilisation in the construction context, it is largely limited to marketing and logistics. However, the research concluded that TT research investigations should not be restricted to examining the direct effects of identified factors and associated variables, but that it is also important to examine causal interactions between factors, so as to achieve an accurate representation of the TT process. The factors and associated variables identified in this investigation were utilised to develop the conceptual model for international TT in construction projects, which is described next.

Conceptualising technology transfer partnerships

The aim of developing a conceptual model for the TT process in the Ghanaian construction industry is to capture all relevant factors that influence the effectiveness of TT, and their resulting value-added creation. These factors have been adapted from the aforementioned previous work on the phenomenon of TT. Through a process of contextualising and categorising variables and conceptualising their relationship with one another, a number of factors were identified. These factors were classified as enabling factors and TT value-added factors. The classification of variables resulted in eight definable factors, namely (i) transferor and transferee characteristics, (ii) the transfer environment, (iii) relationship building and absorptive capability, (iv) government influence, (v) the learning environment, (vi) communication, (vii) project performance, and (viii) knowledge advancement. The project performance factor and the knowledge advancement factor constituted TT value-added creation. The structure of the conceptual framework constructs and the relationship between them have also been conceptualised based on empirical analysis, and testing is therefore required to confirm their appropriateness and validity.

RESEARCH METHOD

Data was acquired from Ghanaian construction professionals in the third quarter of 2014. The target group of respondents included design and construction professionals who were involved in TT initiatives. This study solicited the perceptions of transferees in Ghana only, since TT initiatives are ultimately undertaken for the purpose of improving knowledge levels and enhancing the industry capacity of host participants. Due to inherent difficulties associated with defining the population of construction professionals in Ghana, purposive and snowballing non-probability sampling techniques were used (Berger and Udell, 1988). In total, 120 survey questionnaires were distributed, and 94 were returned, representing a response rate of 78%. The questionnaire survey contained two distinct sections. Section 1 solicited descriptive statistics on the participating respondent (i.e. firm status, firm existence, and professional experience) and the projects they have been involved in where TT programmes were integrated. Section 2 contained questions relating to the enablers for a successful TT process, including the transfer environment, the learning environment, transferor characteristics, transferee characteristics, economic advancement, knowledge advancement, and project performance. These variables contained sub-factors represented in the conceptual framework. Respondents were requested to provide a rating for these variables, measured on a five-point Likert scale, where response options ranged from 1

("not significant") to 5 ("very significant"). Statistical techniques including descriptive analysis and exploratory factor analysis were then used to analyse the data collected.

DATA ANALYSIS AND RESULTS

The effect of legal organisation can affect the behaviour of the firm's activity (Owusu-Manu, 2008). Conventional types of legal organisation considered in this study were enterprises/sole proprietorships, private limited liability, and partnerships/joint ventures. These types of firms represent popular legal forms of businesses in both developed and developing countries (Owusu-Manu, 2008). When asked to indicate the type of legal organisation of their firms, a high majority of respondents, representing 57.5%, were operating as private limited liability firms (PLFs), 28.7% were enterprises/sole proprietorships, and the remaining 13.8% were partnerships/joint ventures. These results suggest the perceived advantage of PLFs as a good sign of credibility and formality of operations (Cassar, 2004).

The age of a firm has been recognised as a critical factor in determining the firm's real activity variables, including growth, financing pattern, and employment. For instance, Evans (1987) revealed that growth rate of the firm and volatility of growth are both negatively associated with firm age. Cabral and Mata (2003) demonstrated that the distribution of the logarithms of firm size of a given cohort is skewed to the right at time of birth, and gradually evolves towards a more symmetric distribution. In particular, these authors indicated that the total firm size distribution, in turn, is fairly stable over time, and therefore skewed to the right. In this regard, Stinchcombe (1965) suggested that older firms are more experienced, have learned more over time, are not susceptible to the liability of newness, and have improved performance. Previously, other authors have considered age of vendor firms as a proxy measure for reduction of asymmetric information between a firm and its financiers (Elliehausen and Wolken, 1990; Berger and Udell, 1998). Drawing from these experiences, the age of the firm would also affect the firm's social obligations. The age levels of the sample firms were gathered. Analysis of the data revealed that 33.0% of the sample firms had been in existence for 10 years or less, 14.9% had been in existence for 20 years or less, 37.2% had existed for 30 years or less, and 14.9% had existed for more than 30 years. The age of the firm will determine the experiences of its employees in the acquisition of knowledge and technology in the TT process. A respondent's years of experience in an organisation allow them to acquire more knowledge and experience of TT. An analysis of respondent experience reveals that 22.3% of respondents had less than 5 years' working experience, 43.6% had 10 years or less, 11.7% had 15 years or less, and 22.3% had 20 years or less. The results indicate that survey respondents had reasonable experience and would provide a balanced view of how the TT process is perceived by construction practitioners.

Factor analysis

Factor analysis is based on the correlation matrix of the variables involved. Correlations require a large sample size before they can stabilise, and a bare minimum of 10 observations per variable is necessary to avoid computational difficulties (Hair et al., 1998; DeCoster, 1998). According to Field (2005), Ahadzie (2007), and Owusu and Badu (2009), factor analysis is useful for finding clusters of related variables and is ideal for reducing a large number of variables into a more easily understood framework. The data sample was deemed adequate for factor analysis, exceeding the observation-to-variable ratio recommended by Hair et al. (1998). Furthermore, the Kaiser-Meyer-Olkin measure of sampling adequacy (KMO) and Bartlett's test of sphericity were

used to measure sampling adequacy within factor analysis (Field, 2005). The KMO measure ranges from 0 to 1, where a value of zero indicates that the sum of partial correlations is large relative to the sum of correlations, indicating diffusion in the patterns of correlation, and thus indicating that factor analysis is inappropriate (Field, 2005; Gorsuch, 1983). A value close to 1.00 indicates that the patterns of correlation are relatively compact, and so factor analysis should yield distinct and reliable factors (Field, 2005). However, the literature recommends that the KMO value should be greater than 0.50 if the sample size is adequate (Coakes, 2005; Field, 2005). Table 1 shows that the KMO was approximately 0.638, which confirms the adequacy of the sample size, and indicates that factor analysis can proceed.

Table 1: The Kaiser-Meyer-Olkin measure of sampling adequacy, and the Bartlett's test of sphericity measure

Kaiser-Meyer-Olkin measure of sampling adequacy		.638
Bartlett's test of sphericity measure	Approx. chi-square	2126.103
	df	300
	Sig.	.000

Similarly, the data has 94 observations per variable, and the communalities after extraction were above 0.6 (see Table 2), which further confirms the adequacy of the sample size. The Bartlett's test of sphericity measure is also statistically significant, since the KMO is above 0.5. These data (the KMO, and the Bartlett's test of sphericity measure) indicate that there is a strong relationship between the enablers of TT variables.

Table 2: Communalities

Variable	**Initial**	**After extraction**
1. Complexity of construction technology	1.000	.898
2. Construction mode of transfer	1.000	.751
3. Government policy	1.000	.838
4. Government enforcement	1.000	.853
5. Cultural differences	1.000	.899
6. Trust	1.000	.695
7. Communication	1.000	.645
8. Training programmes	1.000	.798
9. Teamwork	1.000	.725
10. Willingness to transfer	1.000	.617
11. Level of experience (transferee)	1.000	.790
12. Cultural traits (transferor)	1.000	.884
13. Knowledge base (transferee)	1.000	.636
14. Intent to learn technology	1.000	.872
15. Level of experience (transferor)	1.000	.927
16. Cultural traits (transferee)	1.000	.776
17. Knowledge base (transferor)	1.000	.877
18. Competitiveness	1.000	.646

19. Performance improvement	1.000	.693
20. Improved knowledge	1.000	.845
21. Improved working practices	1.000	.764
22. Long-term adoption of transferred skills	1.000	.755
23. Financial performance	1.000	.795
24. Schedule performance	1.000	.686
25. Quality performance	1.000	.846

Method of extraction: principal component analysis

The statistical significance of the Bartlett's test of sphericity measure also suggests that the population was not an identical matrix, and that relationships thus exist between the variables (Field, 2005). The Bartlett's test measure for this study was highly significant ($p<0.001$), and factor analysis is therefore appropriate. Having satisfied the criteria for data suitability, principal component analysis (PCA) and Varimax with Kaiser Normalization were then used to analyse the data collected. A critical examination of the extraction sums of squared loadings in Table 2 reveals that the average of communalities extracted was above 0.60, which indicates how well the extracted components represent the variables. The extracted components are thus a very good representation of the factors that enable TT. Both the Kaiser-Guttman rule and the Cattell scree test were used to determine the number of factors to be extracted. The Kaiser-Guttman rule suggests that only those factors with an eigenvalue greater than 1 should be retained, while the Cattell scree test suggests that all subsequent components after the one starting at the elbow should not be included. After applying these criteria, eight components were extracted to represent the factors that enable TT factors, or the variables.

Table 3: Total variance explained

Component	**Initial eigenvalues**			**Extraction sums of squared loadings**			**Rotation sums of squared loadings**		
	Total	**% of variance**	**Cum. %**	**Total**	**% of variance**	**Cum. %**	**Total**	**% of variance**	**Cum. %**
1	**4.248**	**16.990**	**16.990**	4.248	16.990	16.990	3.044	**12.178**	**12.178**
2	**3.821**	**15.283**	**32.273**	3.821	15.283	32.273	2.983	**11.933**	**24.111**
3	**2.656**	**10.622**	**42.896**	2.656	10.622	42.896	2.875	**11.502**	**35.612**
4	**2.563**	**10.251**	**53.147**	2.563	10.251	53.147	2.798	**11.192**	**46.804**
5	**2.012**	**8.048**	**61.195**	2.012	8.048	61.195	2.396	**9.584**	**56.387**
6	**1.739**	**6.956**	**68.151**	1.739	6.956	68.151	2.146	**8.584**	**64.971**
7	**1.329**	**5.317**	**73.468**	1.329	5.317	73.468	1.648	**6.594**	**71.565**
8	**1.142**	**4.567**	**78.035**	1.142	4.567	78.035	1.617	**6.470**	**78.035**
9	0.931	3.724	81.759						
10	0.898	3.590	85.349						
11	0.759	3.035	88.384						
12	0.614	2.458	90.842						
13	0.517	2.067	92.908						
14	0.470	1.879	94.788						
15	0.327	1.309	96.097						
16	0.261	1.044	97.141						
17	0.219	0.876	98.017						

18	0.158	0.633	98.650		
19	0.125	0.500	99.150		
20	0.075	0.301	99.451		
21	0.053	0.210	99.661		
22	0.041	0.163	99.824		
23	0.019	0.075	99.900		
24	0.014	0.055	99.955		
25	0.011	0.045	100.000		

Method of extraction: principal component analysis

The total variance explained by each component extracted was 16.990% for component 1, 15.283% for component 2, 10.622% for component 3, 10.251% for component 4, 8.048% for component 5, 6.956% for component 6, 5.317% for component 7, and 4.567% for component 8. In all, the eight components extracted cumulatively accounted for 78.035% of the variation inherent in the data. This therefore implies that eight principal components have been extracted to represent key enablers of TT whose eigenvalues are greater than 1. Rotation can improve the interpretability of results (Norušis, 2005). The rotated factor solution is displayed by default and is essential for interpreting the final rotated analysis. Rotation suggests the behaviour of the variables under extreme conditions; it maximises the loading of each variable on one of the extracted factors, while minimising the loading on all the other factors (Child, 1990). Tables 4 and 5 present the results of the component matrix and the rotated component matrix, respectively, of the principal component analysis.

Table 4: Component matrix[a]

Variable	**Component**							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Complexity of construction technology	.278	-.677	.319	-.210	-.139	.369	-.248	-.012
Construction mode of transfer	.652	-.390	.237	-.189	.117	.083	-.233	.087
Government policy	-.206	.579	.502	.349	.179	.009	.176	.154
Government enforcement	-.467	.434	.604	.118	.136	-.100	.121	.157
Cultural differences	-.554	.265	.547	-.019	-.091	.440	.105	.094
Trust	-.088	-.311	.458	.075	.413	.033	.204	-.403
Communication	.226	.038	.114	-.136	.251	-.527	-.337	.326
Training programmes	.480	.068	.300	-.137	-.249	-.578	.204	.129
Teamwork	.029	.600	.426	-.009	-.080	-.160	-.320	.218
Willingness to transfer	.262	-.608	.053	-.077	.232	.170	-.065	.288
Level of experience (transferee)	.421	.518	-.001	-.395	.272	-.043	-.299	-.153
Cultural traits (transferor)	.594	.101	.217	-.479	.180	-.170	.277	-.325
Knowledge base (transferee)	.095	.555	-.413	-.210	.153	.036	-.214	.185
Intent to learn technology	.425	-.273	-.204	-.076	-.276	.242	.367	.549
Level of experience (transferor)	.316	.556	-.110	-.291	.211	.601	.012	-.123
Cultural traits (transferee)	.459	.037	.179	-.522	-.181	-.213	.415	-.089
Knowledge base (transferor)	.348	.732	-.175	-.326	-.006	.270	.100	.033
Competitiveness	.535	-.048	.413	.270	.075	.082	.286	.142
Performance improvement	.608	.185	.324	.236	.013	.318	-.150	.069
Improved knowledge	.672	.238	-.025	.513	-.256	.067	-.018	-.053
Improved working practices	.438	.161	-.123	.581	-.287	-.082	-.039	-.321
Long-term adoption of transferred skills	.483	-.010	.263	.534	-.251	.012	-.294	-.131

Financial performance	.110	-.342	.199	.079	.775	-.035	-.130	.002
Schedule performance	.253	-.012	-.255	.415	.516	.085	.296	.152
Quality performance	.244	.202	-.534	.455	.445	-.166	.162	.040

Method of extraction: principal component analysis
[a]: eight components extracted

The next stage sought to examine the presence of any complex structure among the variables. A complex structure is present when a variable has a factor or component loading greater than 0.50 on more than one component. Loadings express the influence of each original variable within the component. After checking for the presence of a complex structure in the variables, the factor loadings are again examined, but this time to check for components that have only one variable loading on them. Table 5 shows that all eight components had more than one variable loading on them, and all eight components were therefore retained. What remains is the interpretation of the eight principal components extracted. Note that the original 25 variables have been dimensionally reduced into eight new intercorrelated variables, which explain 78% of the total variance in the variables included on the components. These results show that these factors are significant indicators of enablers of TT in the Ghanaian construction industry.

Table 5: Rotated component matrix[a]

Variable	Component							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Complexity of construction technology	-.156	.088	**.794**	-.230	.021	-.395	-.153	.051
Construction mode of transfer	.086	.228	**.722**	-.232	.256	-.057	.213	.057
Government policy	.071	.143	-.212	**.855**	-.021	.164	.039	.094
Government enforcement	-.079	-.142	-.211	**.861**	-.016	-.075	.101	.159
Cultural differences	.032	-.198	.005	**.757**	-.206	-.342	-.354	.023
Trust	-.260	-.073	.256	.187	.175	.108	-.242	**.649**
Communication	.011	-.041	.127	.008	.128	.070	**.777**	.032
Training programmes	-.154	.239	-.031	.056	**.718**	-.072	.402	-.176
Teamwork	.286	.210	-.143	.541	.009	-.264	.464	-.034
Willingness to transfer	-.174	-.104	.712	-.203	-.016	.146	.051	-.063
Level of experience (transferee)	.745	.074	-.013	-.049	.224	-.045	.353	.225
Cultural traits (transferee)	.340	.035	.150	-.121	.808	.021	.037	.272
Knowledge base (transferee)	.639	-.103	-.242	-.071	-.147	.138	.272	-.199
Intent to learn technology	-.041	.033	.400	-.163	.234	.187	-.174	-.750
Level of experience (transferor)	.908	.049	.086	.085	.041	.069	-.281	.007
Cultural traits (transferor)	.137	-.045	.062	-.092	.843	-.139	-.014	-.111
Knowledge base (transferor)	.844	.069	-.184	.103	.231	.043	-.057	-.240
Competitiveness	-.065	.430	.396	.290	.371	.269	-.056	-.056
Performance improvement	.319	.610	.402	.218	.078	.054	.018	-.030
Improved knowledge	.147	.856	-.005	-.043	.113	.194	-.013	-.194
Improved working practices	-.034	.802	-.251	-.176	.028	.138	-.070	.013
Long-term adoption of transferred skills	-.101	.836	.159	.022	-.042	-.073	.099	.060
Financial performance	-.073	-.146	.509	.033	-.071	.420	.225	.525
Schedule performance	.039	.106	.126	.005	-.054	.806	-.071	.001
Quality performance	.127	.181	-.241	-.186	-.107	.824	.118	.002

Method of extraction: principal component analysis
Rotation method: Varimax with Kaiser Normalization
[a]: Rotation converged in 16 iterations

DISCUSSION AND INTERPRETATION OF RESULTS

To discuss and interpret the results, the procedure proposed by Leedy and Ormrod (2005) was adopted, which relates the research findings to hypotheses advanced, connects the findings to existing literature, concepts, theories, and previous research studies, determines if the findings have practical and statistical significance, and identifies limitations of the research. Based on a critical examination of the inherent relationships among the variables under each component, the following underlying dimensions were deduced: component 1: transferor and transferee characteristics; component 2: knowledge advancement; component 3: transfer environment; component 4: government influence; component 5: learning environment; component 6: project performance; component 7: communication; component 8: relationship building. These labels were derived based on the interrelated characteristics of the variables, and their combination with high factor loadings.

Component 1: Transferor and transferee characteristics (PC1)

PC1 in Table 6 reported high factor loadings for the variables "level of experience (transferee)" (0.745), "knowledge base (transferee)" (0.639), "level of experience (transferor)" (0.908), and "knowledge base (transferor)" (0.844).

Table 6: Component profile of the enablers of TT

Description of components and variables	Factor loading	Variance explained
Component 1: Transferor and transferee characteristics		
1. Level of experience (transferee)	.745	**16.990%**
2. Knowledge base (transferee)	.639	
3. Level of experience (transferor)	.908	
4. Knowledge base (transferor)	.844	
Component 2: Knowledge advancement		
1. Performance improvement	.610	**15.283%**
2. Improved knowledge	.856	
3. Improved working practices	.802	
4. Long-term adoption of transferred skills	.836	

Component 3: Transfer environment		
1. Complexity of construction technology	.794	**10.622%**
2. Construction mode of transfer	.722	
3. Willingness to transfer	.712	
Component 4: Government influence		
1. Government policy	.855	**10.251%**
2. Government enforcement	.861	
3. Cultural differences	.757	
Component 5: Learning environment		
1. Training programmes	.718	**8.048%**
2. Cultural traits (transferee)	.808	
3. Cultural traits (transferor)	.843	
Component 6: Project performance		
1. Schedule performance	.806	**6.956%**
2. Quality performance	.824	
Component 7: Communication		
1. Communication	.777	**5.317%**
Component 8: Relationship building and absorptive capability		
1. Trust	.649	**4.567%**
2. Intent to learn technology	-.750	

The values in brackets indicate the respective factor loadings, which assume the relative importance of the variable in the data set of the component. The cluster of variables in component 1 accounted for 16.990% of the variance explained, as shown in Table 3. The chi-

square test revealed that there was a significant key relationship between level of experience, knowledge base, level of experience, and knowledge base as enablers of TT.

Component 2: Knowledge advancement (PC2)

PC2 in Table 6 reported high factor loadings for the variables "performance improvement" (0.610), "improved knowledge" (0.856), "improved working practices" (0.802) and "long-term adoption of transferred skills" (0.836). The component accounted for 15.283% of the variance explained, as shown in Table 3. The chi-square test for significance revealed that a significant key relationship exists between performance improvement, improved knowledge, improved working practices, and long-term adoption of transferred skills as enablers of TT.

Component 3: Transfer environment (PC3)

The variables extracted under PC3 include "complexity of construction technology", "construction mode of transfer", and "willingness to transfer", with eigenvalues of 0.794, 0.722, and 0.712, respectively. The component accounted for 10.622% of the variance explained, as shown in Table 3. The chi square test failed to reject the null hypothesis relation to construction mode of transfer, hence, it is not dependent on the transfer environment as an enabler of TT. However, the chi square test revealed that there is statistical evidence to advocate the dependency of complexity of construction technology and willing to transfer were dependent on the transfer environment as enablers of TT.

Component 4: Government influence (PC4)

The variables extracted under PC4 include "government policy", "government enforcement", and "cultural differences", with eigenvalues of 0.855, 0.861, and 0.757, respectively. The component accounted for 10.251% of the variance, as shown in Table 3. The chi square test rejected the null hypothesis for all extracted variables, hence, there is a statistical evidence of dependency amongst these variables upon government influence as an enabler of TT.

Component 5: Learning environment (PC5)

The variables extracted under PC5 include "training programmes", "cultural traits (transferee)", and "cultural traits (transferor)", with eigenvalues of 0.718, 0.808, and 0.843, respectively. The component accounted for 8.048% of the variance (see Table 3). The chi square test rejected the null hypothesis for all extracted variables, hence statistical evidence of dependency amongst these variables upon the learning environment as an enabler of TT.

Component 6: Project performance (PC6)

The variables extracted under PC6 include "schedule performance" and "quality performance", with eigenvalues of 0.806 and 0.824, respectively. The component accounted for 6.956% of the variance explained (see Table 3). The component accounted for 6.956% of the variance explained (refer to Table 3). The chi square test rejected the null hypothesis in relation to all extracted variables, hence, there is statistical evidence of dependency amongst these variables upon the project performance as an enabler of TT.

Component 7: Communication (PC7)

The variable extracted under PC7 is "communication", with an eigenvalue of 0.777. The extracted component accounted for 5.317% of the variance explained (see Table 3). The chi

square test rejected the null hypothesis relation to the extracted variable, hence there is statistical evidence of dependency amongst these variables upon communication as an enabler of TT. Previous authors have stressed the importance of effectiveness of communication between transferor and transferee and its impact on the TT process (Devapriya and Ganesan, 2002; Ganesan and Kelsey, 2006; Malik, 2002).

Component 8: Relationship building and absorptive capability (PC8)

The variables extracted under PC8 include "trust" and "intent to learn technology", with eigenvalues of 0.649 and -0.750, respectively. The component accounted for 4.567% of the variance explained (see Table 3). The chi square test rejected the null hypothesis relation to the extracted variable, hence there is statistical evidence of dependency amongst these variables upon relationship building and absorptive capability as an enabler of TT. For TT to function efficiently and effectively, organisations involved in the TT process should build a culture of mutual trust, through effective communication between transferor and transferee (Malik, 2002). Cohen and Levinthal (1990) adjusted this macroeconomic concept and viewed absorptive capacity as a firm-level construct. Cohen and Levinthal (1989) introduced the absorptive capacity construct as the firm's ability to identify, assimilate, and exploit knowledge from the environment. They argue that absorptive capacity depends greatly on prior related knowledge and diversity of background. They assume that a firm's absorptive capacity tends to develop cumulatively and is dependent on the absorptive capacity of its individual members.

Using these eight components and variables, a conceptual framework that reflects TT in the Ghanaian construction sector was constructed (see Figure 1). This model illustrates the typologies of technology that impact upon transferor characteristics, and their interaction with the transfer environment. These aforementioned factors, together with facilitating success factors and risk factors, impact upon the transferee characteristics that lead to TT value-added creation and its links with knowledge advancement and project performance. Further qualitative work is, however, required to develop new concepts and theories, so as to provide a richer explanation of the factors and variables uncovered in this research. To simply state that a variable or factor is statistically significant does not explain why it is significant. Any such further work would almost certainly complement this research and could form the basis for future tools that assess and evaluate the performance of TT in the construction sector of DCs. Such tools are urgently needed, as current means of evaluation are largely subjective and/or impractical to implement.

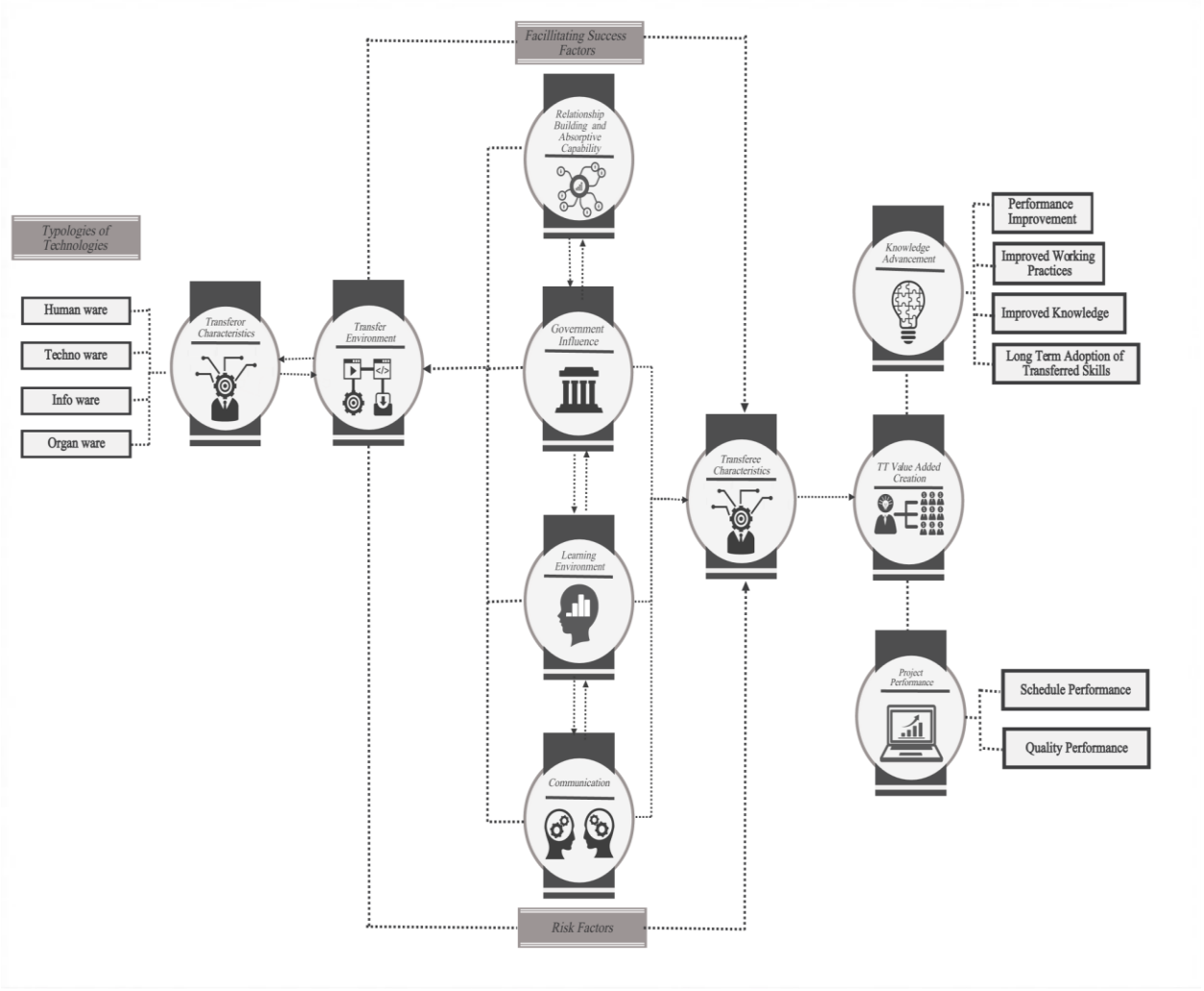

Figure 1: A conceptual framework for technology transfer partnerships

CONCLUSIONS

This study examined the prospect of technology transfer (TT) promoting development of construction companies in host developing countries (DCs), as receivers and users of construction technology. A review of existing TT literature provided a comprehensive understanding of the evolution and development of previous TT models, and the significant influence of knowledge advancement and project performance in shaping current and future TT models. In other industrial sectors, TT initiatives represent the first step towards efficiently and effectively transforming or re-engineering traditional business processes, and ultimately improving productivity performance. In a construction context, more research should be conducted to exploit the inherent potential of TT and expand upon the largely qualitative research conducted within this paper. TT does not, however, occur naturally, and so the processes that underpin TT should be continuously evaluated, so as to ensure that knowledge and skills are being seamlessly absorbed by indigenous workers. The derived TT framework could be utilised to assist government officers in DCs to better evaluate TT performance. TT stakeholders will also benefit from knowledge of the significant pathways to achieving value from the TT process. Understanding the dynamics of such pathways (perhaps using system dynamics) will

assist industry and government to better structure TT arrangements and concentrate on the most empowering enablers.

The conceptual framework presented is especially important for publicly funded infrastructure in Ghana, where the government is concerned about whether advanced technologies are being willingly and effectively transferred to local workers and professionals. In addition, the framework could assist multilateral funding agencies, such as the World Bank, which need tools to better monitor the performance of the TT process and provide loans for infrastructure development. One of the primary objectives of these funding agencies is to actively encourage domestic firms in DCs to improve the knowledge levels of their workers, as well as industry capacity, ultimately leading to improved standards of living for all indigenous people. Future studies should seek to determine the relationship between perceptions of culture, physical environment, and geographical location and the success of TT. In addition, the conceptual model presented must be validated using system dynamics, structural equations, and/or methods of benchmarking, so as to strengthen evaluation of baseline performance of the construction TT process in Ghana and other DCs.

ACKNOWLEDGEMENT

This article was language-edited by a freelance language editor, Anthony Sparg. He has edited several academic journal articles and master's theses in the field of construction management. He has an MA *cum laude* in African Languages (isiXhosa), an MA *cum laude* in Linguistics, and a Higher Diploma in Education.

REFERENCES

Agmon, T. and Glinow, V.M. (eds). (1991). *Technology transfer in international business*. New York: Oxford University Press.

Ahadzie, D.K. (2007). *A model for predicting the performance of project managers in mass house building projects in Ghana*. PhD thesis. Wolverhampton, UK: University of Wolverhampton.

Baerz, A.M., Abbasnejad, T., Rostamy, A.A.A. and Azar, A. (2010). Exploring of the role and position of institutional actors in the university-industry interactions. *World Applied Sciences Journal*, 11(11), 1432–1438.

Berger, A.N. and Udell, G.F. (1998). The economics of small business finance: The roles of private equity and debt markets in the financial growth cycle. *Journal of Banking & Finance*, 22(6–8), 613–673.

Boddewyn, J.J. (1966) A Construct for Comparative Marketing Research, Journal of Marketing Research, Vol. 3, No. 2, pp. 149-153.

Boddewyn, J.J. (1981) Comparative Marketing: The First Twenty-Five Year, Journal of International Business Studies, Vol.12, No. 1, pp. 61-79.

Bozeman, B. (2000). Technology transfer and public policy: A review of research and theory. *Research Policy*, 29(4–5), 627–655.

Cabral, L.M.B. and Mata, J. (2003). On the evolution of the firm size distribution: Facts and theory. *American Economic Review*, 93(4), 1075–1090.

Calantone, R.J., Lee, M.-T. and Gross, A.C. (1990). Evaluating international technology transfer in a comparative marketing framework. *Journal of Global Marketing*, 3(3), 23–46.

Cassar, G. (2004). The financing of business start-ups. *Journal of Business Venturing*, 19(2), 261–283.
Child, D. (1990). *The essentials of factor analysis*. 2nd ed. London: Cassel Educational Ltd.
Coakes, S.J. (2005). *SPSS: Analysis without anguish: Version 12.0 for Windows*. Sydney, Australia: John Wiley & Sons Australia.
Cohen, W.M. and Levinthal, D.A. (1990). Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly*, 35(1), 128–152.
Cohen, W.M. and Levinthal, D.A. (1989). Innovation and learning: The two faces of R&D. *The Economic Journal*, 99(397), 569–596.
DeCoster, J. (1998). *Overview of factor analysis*. Tuscaloosa, AL: Department of Psychology, University of Alabama.
Devapriya, K.A.K. and Ganesan, S. (2002). Technology transfer through subcontracting in developing countries. *Building Research & Information*, 30(3), 171–182.
Elliehausen, G.E. and Wolken, J.D. (1990). *Banking markets and the use of financial services by small and medium-sized businesses (Staff Studies 160)*. Washington, DC: Board of Governors of the Federal Reserve System.
Evans, D.S. (1987). The relationship between firm growth, size, and age: Estimates for 100 manufacturing industries. *The Journal of Industrial Economics*, 35(4), 567–581.
Field, A. (2005). *Discovering statistics using SPSS for Windows*. 2nd ed. London: Sage.
Ganesan, S. and Kelsey, J. (2006). Technology transfer: International collaboration in Sri Lanka. *Construction Management and Economics*, 24(7), 743–753.
Gibson, D.V. and Smilor, R.W. (1991). Key variables in technology transfer: A field-study based empirical analysis. *Journal of Engineering and Technology Management*, 8(3–4), 287–312.
Gorsuch, R.L. (1983). *Factor analysis*. 2nd ed. Hillsdale, NJ: Lawrence Erlbaum Associates.
Hair, J.F., Anderson, R.E., Tatham, R.L. and Black, W.C. (1998). *Multivariate data analysis*. Upper Saddle River, NJ: Prentice-Hall.
Henriod, E.E. (1984). *The construction industry: Issues and strategies in developing countries*. Washington, DC: World Bank.
Kumar, V., Kumar, U. and Persaud, A. (1999). Building technological capability through importing technology: The case of Indonesian manufacturing industry. *The Journal of Technology Transfer*, 24(1), 81–96.
Kumaraswamy, M.M. (2006). Accelerating construction industry development. *Journal of Construction in Developing Countries*, 11(1), 73–96.
Lam, A. (1997). Embedded firms, embedded knowledge: Problems of collaboration and knowledge transfer in global cooperative ventures. *Organization Studies*, 18(6), 973–996.
Leedy, P.D. and Ormrod, J.E. (2005). *Practical research: Planning and design*. 8th ed. Upper Saddle River, NJ: Pearson Prentice Hall.
Lewis, P. (1998). Trunkliner program scrapped. *Flight International*, 29 July – 4 August, 4.
Lin, B.-W. and Berg, D. (2001). Effects of cultural difference on technology transfer projects: An empirical study of Taiwanese manufacturing companies. *International Journal of Project Management*, 19(5), 287–293.
Lundquist, D.G. (2003). A rich vision of technology transfer technology value management. *The Journal of Technology Transfer*, 28(3/4), 284–312.
Malik, K. (2002). Aiding the technology manager: A conceptual model for intra-firm technology transfer. *Technovation*, 22(7), 427–436.

Moavenzadeh, F. and Hagopian, F. (1984). The construction industry and economic growth. *Asian National Development*, June/July, 56–60.

Moxon, J. and Lewis, P. (1998). Airbus industries and AVIC abandon AE31X. *Flight International*, 8–14 July, 6.

Nonaka, I. and Takeuchi, H. (1995). *The knowledge-creating company: How Japanese companies create the dynamics of innovation*. New York: Oxford University Press.

Norušis, M.J. (2005). *The SPSS guide to data analysis for SPSS-X*. Chicago: SPSS Inc.

Osman-Gani, A.A.M. (1999). International technology transfer for competitive advantage: A conceptual analysis of the role of HRD. *Competitiveness Review: An International Business Journal*, 9(1), 9–23.

Owusu, M.D. and Badu, E. (2009). Determinants of contractors' capital investment finance strategy in Ghana. *Journal of Financial Management of Property and Construction*, 14(1), 21–33.

Owusu-Manu, D. (2008). *Equipment investment finance strategy for large construction firms in Ghana*. PhD dissertation. Department of Building Technology, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.

Ramanathan, K. (1994). The polytrophic components of manufacturing technology. *Technological Forecasting and Social Change*, 46(1), 20–35.

Saad, M., Cicmil, S. and Greenwood, M. (2002). Technology transfer projects in developing countries—furthering the Project Management perspectives. *International Journal of Project Management*, 20(8), 617–625.

San, M.M. (2004). Technology transfer a need for development of building sector. *The Myanmar Times*. Available at: http://www.myanmar.com/myanmartimes/MyanmarTimes12-235/025.htm

Sexton, M. and Barrett, P. (2004). The role of technology transfer in innovation within small construction firms. *Engineering, Construction and Architectural Management*, 11(5), 342–348.

Simkoko, E.E. (1989). *Analysis of factors impacting technology transfer in construction projects: Case studies from developing countries*. Stockholm, Sweden: Swedish Council for Building Research.

Simkoko, E.E. (1992). Managing international construction projects for competence development within local firms. *International Journal of Project Management*, 10(1), 12–22.

Smith, D.K. and Alexander, R.C. (1988). *Fumbling the future: How Xerox invented, then ignored, the first personal computer*. New York: William Morrow.

Sridharan, G. (1994). Managing technology transfer in construction joint ventures. *American Association of Cost Engineers Transactions, Morgantown*, 15, 6.1–6.4.

Stewart, R.A. and Waroonkun, T. (2007). Benchmarking construction technology transfer in Thailand. *Construction Innovation: Information, Process, Management*, 7(3), 218–239.

Stinchcombe, A.L. (1965). Social structure and organizations. In: J. G. March (ed.). *Handbook of organizations*. Chicago: Rand McNally.

Tatum, C.B. (1988). Classification system for construction technology. *Journal of Construction Engineering & Management*, 114(3), 334–363.

Van Egmond, E. and Erkelens, P. (2007). Technology and knowledge transfer for capability building in the Ghanaian construction industry. *Construction for Development,*

Information and Knowledge Management in Building (W102), CIB World Building Congress. 14–17 May. Cape Town. pp. 1393–1405.

Wang, P., Tong, T.W. and Koh, C.P. (2004). An integrated model of knowledge transfer from MNC parent to China subsidiary. *Journal of World Business*, 39(2), 168–182.

Waroonkun, T. and Stewart R.A. (2008). Modeling the international technology transfer process in construction projects: Evidence from Thailand. *The Journal of Technology Transfer*, 33(6), 667–687.

Wilson, I. (1986). The strategic management of technology: Corporate fad or strategic necessity? *Long Range Planning*, 19(2), 21–22.