Received 16 November 2016
Revised 27 March 2017
9 June 2017
Accepted 10 August 2017

LiVE approach: Lean integrated Value Engineering for construction industry

E.M.A.C. Ekanayake and Y.G. Sandanayake
Department of Building Economics,
University of Moratuwa, Moratuwa, Sri Lanka

Abstract

Purpose – Increasing demand for the best value for client's money necessitates waste reduction while enhancing the project functionality in construction industry. The purpose of this paper is to propose Lean integrated Value Engineering (LiVE) approach by establishing the synergy between Lean and Value Engineering (VE) concepts for construction industry.

Design/methodology/approach – A literature survey and in-depth un-structured interviews with six subject matter experts in three steps were used to investigate the synergy between Lean principles and VE job plan to develop LiVE approach for the construction industry. The gathered data were analysed using code-based content analysis and the LiVE approach was finally validated using interviews by two additional subject matter experts representing industry and academia.

Findings – Research findings established that there is a synergy between Lean principles and VE job plan. Accordingly, the study developed a LiVE approach, which specify client's value, identify the value stream, make value flow without interruption, let the client pull functional requirements and pursue perfection during "value establishment", "value analysis of functional requirements", "value creativity", "value evaluation", "value development", "value verification" and "value achievement" phases.

Originality/value – The novel LiVE approach will guide construction industry practitioners on how to integrate Lean concept with VE in order to reduce unnecessary costs and wastes, to enhance project functionality and ultimately to achieve value for client's money.

Keywords Construction industry, Lean, Synergy, Value engineering,
Lean integrated Value Engineering concept, Live approach, Value for client's money

Paper type Research paper

1. Introduction

Globalisation and fierce competition among businesses have necessitated the organisations to achieve value for customers and continuous improvement in every business aspect. Hence, companies tend to achieve competitive edge by bringing significant reforms to the construction industry to achieve the objectives of value addition, waste minimisation, superior performance, overall satisfaction and harmony within the built environment (Anerao and Deshmukh, 2016, Palaneeswaran *et al.*, 2003). Moreover, the construction organisations are forced to rethink about strategies that improving productivity, quality and efficiency of their processes in order to gain the value for money (Karna and Jonnonen, 2005). In this context, construction organisations around the world have constantly been serving to improve value for client's money, either through the elimination of waste using philosophies such as Lean or the identification and adoption of necessary functions using concepts such as Value Engineering (VE) on their projects. According to Tauriainen *et al.* (2016), Lean in its simplest form emphasises on delivery of better value to the customers by eliminating waste from every stage of a work process in construction projects. Salem and Zimmer (2005) identified Lean construction as a continuous process of eliminating waste, meeting or exceeding all customer requirements, focusing on the entire value stream and pursuing perfection in the execution of a constructed project. On the other hand, VE is a systematic approach, which seeks to achieve value for money by providing all necessary functions at the lowest total

Built Environment Project and Asset Management
Vol. 7 No. 5, 2017
pp. 518-533

2044-124X
DOI 10.1108/BEPAM-11-2016-0071

cost (Male *et al.*, 2007). Zhang *et al.* (2009) and Chavan (2013) identified VE as one of the most appropriate and systematic techniques to regulate and improve value in construction projects.

Focusing on the nature and implications of Lean and VE, Cell and Arratia (2003) highlighted that integration of VE with Lean can leverage, accelerate and amplify efforts to implement Lean principles in an organisation. In turn, Lean can enhance the effectiveness of VE efforts. Having considered the strengths and weaknesses of both concepts, Shekari and Fallahian (2007) identified a new way of linking the concepts by developing an algorithm to win the competition and challenges faced by the manufacturing industry. Further, Mandelbaum *et al.* (2010) highlighted the importance of synergising Lean Six Sigma and VE to obtain improvements beyond the capability as individual approaches. Therefore, it is evident that the synergy of VE and Lean philosophy could offer continuous improvement while enhancing the value in their process in manufacturing industry.

Over the years, however, there has been no effort at integration of VE and Lean philosophy in construction industry. This paper, therefore, strives to investigate the synergy between Lean and VE concepts and develop a Lean integrated Value Engineering (LiVE) approach for construction industry.

2. Literature review

2.1 Lean and VE as value achieving strategies

The main focus of Lean concept is to eliminate non-value adding activities in all processes whereas VE aims to enhance project functionality at minimum cost. Although Lean and VE have two distinct approaches, they have one common focus, i.e. achieving value for client's money. The following sections present salient features of these two concepts followed by the comparison in order to understand and establish the synergy between them.

According to Mandujano *et al.* (2017), Lean is a management philosophy, which focuses on identifying wastes and utilising its tools and principles to minimise or eliminate wastes. Womack and Jones (1996) identified value as the most crucial starting point for Lean thinking and further to them, value can only be defined by the ultimate customer, when a specific product or a service meets the customer's need at a specific price and time. They summarised Lean thinking into five principles:

(1) precisely specify value by specific product;

(2) identify the value steam for each product;

(3) make value flow without interruptions;

(4) let the customer pull from the producer; and

(5) pursue perfection.

The founders of International Group for Lean Construction initiated the term "Lean Construction" in 1993 and since then research development and implementation of Lean construction advanced and diffused to all continents (Koskela, 2004). Lean philosophy emerged to Lean construction and its tools are effectively used in the construction to tackle some of the issues in construction management (Sudhakar and Vishnuvardhan, 2017). Lean construction applies a new form of production management to construction sector, which includes performance maximisation, concurrent design and construction and the proper project control throughout the project life cycle from design to delivery (Aziz and Hafez, 2013). Based on the case study findings in India, Anerao and Deshmukh (2016) stated that Lean construction focuses on the holistic pursuit of concurrent and continuous improvements in all dimensions of the built and natural environment such as design, construction, activation, maintenance, salvaging and recycling. In the present construction

context, Lean construction tools are widely used to deliver value to their customers during project life cycle (Mandujano *et al.*, 2017).

However, findings of Issa (2013) confirm that Lean construction does not address the risk factors such as change in material prices or price escalation, delay in running bill payments to the contractor, design errors and poor quality of local materials. Moreover, in its current context, Lean does not directly focus on project functionality during its non-value adding activity elimination exercise, which is vital in achieving the best value for money. There is, therefore, a need to ensure project functionality at optimum cost that could be achieved by leveraging Lean with another concept such as VE, which ensures project functionality in its value achieving exercise.

Chen *et al.* (2010) identified VE as an organised application that uses both of common sense and technical knowledge to locate and eliminate unnecessary project costs and thereby ensure value for money. Zhang *et al.* (2009) identified VE as a management tool, which used in achieving essential functions of a product, service or project with a lowest cost, whereas, Male *et al.* (2007) mentioned VE as a methodological value enhancing management style. VE process investigates constructability, manufacturability and maintainability of a project at the early stage and thereby resolves possible subsequent conflicts (Nawi *et al.*, 2014). It has been widely practiced in the construction industry and became an important part of civil infrastructure projects since the commencement (Zhang *et al.*, 2009). Kelly *et al.*'s (2004) findings confirmed that value can be increased by improving the function or reducing the cost. Further to the authors, VE has been practiced by UK construction industry for the purpose of improving the function and achieved its benefits. VE introduced in Hong Kong since 1980s and widely accepted since Asian financial crisis (Shen *et al.*, 2004). Moreover, Malaysian Highway Construction projects achieved time reduction, cost reduction and quality enhancement by implementing VE practices (Ismail *et al.*, 2010). Further to Perera *et al.* (2011), VE is not a cost cutting exercise, but it has an ultimate goal of delivering best value or ensuring value for money from a project.

The VE job plan used by the US Army Corps of Engineers historically consisted with five phases: information, speculation, analysis, development and presentation (Ellegant, 1979). The job plan has been developed over the years and currently has three main phases with several sub-phases (Kelly *et al.*, 2004; Shen *et al.*, 2004) as follows:

(1) Pre-study – collect customer attitude, determine evaluation factors, scope the study, build data models, determine team composition.

(2) Value study including six sub-phases:

- Information – complete data package, modify scope.
- Functional analysis – identify and classify functions, develop function models, establish function worth.
- Creativity – create large quantity of ideas to achieve the functions specified.
- Evaluation – rank alternative ideas, select ideas for development.
- Development – conduct cost benefit analysis, complete technical data package, create implementation plan, prepare final proposals.
- Presentation – present oral report.

(3) Post-study – complete changes, implement changes, monitor status.

Highlighting the importance of having a database of ideas to be used during the above phases, Park *et al.* (2016) recently proposed a BIM-based VE Idea Bank to enable the systematic retrieval of past VE data and efficient generation of new ideas. These phases are

widely used by the researchers and practitioners in the construction industry for VE and hence used in this study for deriving the synergy between the concepts.

As evident in the above discussion, there are similarities and differences in terms of characteristics, issues, problems and objectives associated with the concepts other than their main focus, i.e. achieving value for money. Table I presents the comparison of Lean and VE concepts.

According to the above comparison, Lean and VE concepts provide systematic approaches to reduce unnecessary cost, time and wastage, and to ensure project functionality. The ultimate objective of both concepts is to achieve value for client's money. However, one of the major differences identified between two concepts is that Lean is a philosophy, whereas VE is an analytical tool. Although Lean is effective, it does not provide answers to all the problems (Cell and Arratia, 2003) and needs more effort to explore ways to overcome the drawbacks associated with the philosophy (Garbie, 2010). On the other hand, although VE facilitates creativity, innovative ideas, alternative solutions and generally indulge in some "out-of-the-box" thinking in introducing proper changes to the construction procedures (Ellis *et al.*, 2005), Fong *et al.* (2001) argued that there is lack of understanding on the real VE practices amongst some clients and construction professionals and this will

	Lean concept	Value engineering (VE)
Origin	Ford and Toyota Production System	General Electric Co
Overview	Philosophy or a strategy	Analytical tool or an approach
Objective	Enhance customer value through waste elimination	Ensure value for the money
Approach	Systematic approach	Systematic approach
Performance	Improve performance	Achieve essential functions
Key success factors	Proper planning, commitment from top management, team working, proper training on Lean principles	Proper planning, attracting top managers, teamwork training, proper communication, multidisciplinary team with experience
Cost	Reduce costs of waste and increase the value	Achieve optimum cost and enhance value
Quality	Achieve by perfection	Enhance the value by achieving optimum quality
Time	Obtain by reducing unnecessary flow activities	Propose alternatives to accelerate the project
Customer satisfaction	Identify and address the customer requirements in customer value phase	Identify customer requirements in pre-study phase and address them during job plan
Potential other savings	Limited by underlying design characteristics	Obtainable by making design changes
Waste elimination	Continuous waste reduction	Spontaneous and quick response to the wastes
Use of analytical tools and techniques	Spaghetti diagrams, flow diagrams, bar charts, standard work sheets, production control boards, 5S, Kaizen, Kanban, TQM, Jidoka, Pokayoke, TPS, value steam mapping to name few	Function analysis using FAST diagrams, decision tree, value index, weight matrix, Pareto charts to name few
Creative thinking and innovations	There is less room for creative process improvement	Facilitates creative process improvements
Suitability	Suitable for variety of situations and high cost reduction is possible in large scale projects	Suitable for variety of situations but VE cost is significant
Management and team dynamics	Team based approach together with the management	VE team based approach
Operation	Based on number of principles to be followed	Based on number of phases to be followed

Sources: Shekari and Fallahian (2007), Wixson (2005), Cell and Arratia (2003)

Table I.
Comparison of Lean and VE concepts

result the unsuccessful VE process implementation. Significant cost and time consumption of the implementation process can be considered as another drawback associated with VE implementation (Kelly *et al.*, 2004).

2.2 Synergy between Lean and VE concepts

Having considered the pros and cons of Lean and VE, Wixson (2005) highlighted the importance of combining Lean and VE to provide answers to the causes of poor performance and high costs in industries, and hence to increase customer value by optimising costs, quality and delivery. Further to the author, Lean and VE could implement together without having conflicts between two concepts. Moreover, Cell and Arratia (2003) stated that Lean and VE concepts can be interacted in manufacturing industry. Further, Shekari and Fallahian (2007) mentioned that integration of these two concepts is essential and could aim better results comparing to their separate implementation. The authors further proposed an algorithm using a flowchart by integrating Lean and VE concepts in order to realise the benefits and solve some problems that cannot be solved by applying the concepts individually in manufacturing industry. Mandelbaum *et al.* (2010) further explored the synergies between Lean Six Sigma and VE by identifying opportunities where they can be used together to increase allied benefits through improvements beyond the capabilities of individual approaches.

Although the above studies highlighted the possibility and importance of integrating Lean and VE concepts to obtain enhanced value for money in manufacturing industry, there is a lack of a study which investigates the synergy between these two concepts and the applicability of an integrated approach to construction industry. Hence, this research aims to investigate the synergy between Lean and VE concepts and to develop a LiVE approach for construction industry. This aim is achieved by answering to the following two main questions relating to the construction industry:

- Q1. How could the Lean principles and VE job plan be integrated by exploring the synergy between two concepts?
- Q2. How could LiVE concept be implemented using a systematic approach, i.e. LiVE approach, while strengthening enablers and addressing challenges?

This novel LiVE approach will focus on identifying and reducing unnecessary costs and wastes associated with the project, while enhancing the functionality of project activities, achieving stakeholder's satisfaction and ultimately delivering value for client's money.

3. Methodology

The research design of this study includes a comprehensive literature survey, in-depth unstructured interviews with experts, data analysis and validation of the research findings. A literature review was conducted to review the Lean and VE concepts and to investigate the possibility of integrating the two concepts in other industries. The literature findings of Mandelbaum *et al.* (2010), Shekari and Fallahian (2007), Wixson (2005) and Cell and Arratia (2003) highlighted the possibility and importance of integrating two concepts to optimise the value for customer in manufacturing industry.

Having considered the exploratory nature of the study, this research was then subjected to a qualitative research approach using in-depth interviews with six subject matter experts using an unstructured interview guideline developed under the aforementioned two main questions. The data collection conducted in three steps as follows:

(1) Step I: interviews with six experts to identify the synergy between Lean principles and VE job plan (using Q1). The findings of the literature review and expert opinions were used to establish the synergy between Lean and VE concepts and hence to develop a basis for LiVE concept.

(2) Step II: interviews with the same experts to verify the basis developed in Step I and to develop LiVE concept with a definition and the phases.

(3) Step III: interviews with the same experts to identify an approach to be followed in implementing the LiVE concept and hence to develop the LiVE approach. It is also expected to identify enablers and barriers in implementing LiVE approach (using Q2).

During Step I, six subject matter experts, who have experience in implementing Lean and VE concepts to construction projects, were selected through purposive sampling and interviewed to identify the synergy between Lean principles and VE job plan. Collection of in-depth information from the experts was conducted until data saturation is reached. Code-based content analysis technique with NVivo 10 software was used for data analysis in all aforementioned steps. The details of the six respondents (*R*) are shown in Table II.

The proposed LiVE concept with its implementation approach was eventually presented to two other subject matter experts for validation. Details of the validation are given in Section 5.

4. Research findings and discussion

This section presents the research findings of the three steps proposed in the above section.

4.1 Step I: identify the synergy between Lean principles and VE job plan and establish a base for LiVE concept

During Step I, six respondents were posed with Q1 to identify the synergy between five Lean principles and eight phase VE job plan in construction projects. They were requested to identify the ability to integrate and apply five Lean principles at each VE phase, and to propose what can be done and/or achieved by implementing Lean principles at the identified VE phase, based on their past experience and knowledge.

Six interview findings were analysed using code-based content analysis to establish the synergy between two concepts and the summary of findings are presented in Table III.

According to the above findings, client's perception on intended value from the project, project scope and expected perfection can be specified at the pre-study phase. Further, the project scope can be modified to establish perfection and accommodate actual requirements of the client with expected value, during the information phase. Findings

Respondent	Details
R1	General Manager (Projects) in a reputed property development company. He has over 35 years of experience and lead the team in implementing Lean and VE in two landmark building projects in Sri Lanka
R2	Director in a Consultancy organisation with over 25 years of experience including implementation of Lean and VE concepts to domestic construction projects
R3	Project Manager with over 25 years of experience in the construction industry and has experience in implementing Lean and VE concepts in both local and international construction projects
R4	Construction Manager attached to a Grade 1 Contractor in Sri Lanka and has over 25 years of experience. He has experience in implementing both concepts to several building projects in Sri Lanka
R5	Chief Quantity Surveyor who has over 20 years of experience working in a leading construction organisation. The organisation has conducted VE exercise for all recent construction projects and applied Lean concept in all projects
R6	Facilities Manager and a Researcher specialised in the both fields and involved in several new construction projects from inception to completion, during past 10 years

Table II.
Details of the respondents

Table III.
Synergy between Lean and VE concepts – summary of findings

	Lean principle					
	Customer value	Value stream	Flow	Pull	Perfection	Synergy
Value engineering job plan						
Pre-study phase	R1-3: Pre-study phase and customer value can be mapped. R4-6: Identifying and specifying the clients perception and project scope can be achieved at this phase	R1-6: No significant synergy	R1-6: No significant synergy	R1-6: No significant synergy	R2 and R6: Perfection can be defined in this phase	Client's value, project scope and perfection can be specified at pre-study phase
Value-study phase						
Information phase	R1, R3 and R4: There is a link between information phase and customer value and hence can be mapped R5-6: Value can be established with actual client requirements at this phase	R1-6: No significant synergy	R1-6: No significant synergy	R1-6: No significant synergy	R2 and R6: Project scope can be modified to establish perfection	Project scope and client requirements can be established to achieve client's value and perfection at Information Phase
Functional analysis phase	R1-6: No significant synergy	R1-3 and R6: Value stream mapping can be used to enhance Client's functional requirements	R1-6: No significant synergy	R1-6: Functional requirements can be pulled from the client at this stage	R1-6: No significant synergy	Client pulled functional requirements can be enhanced using value stream mapping at the Functional Analysis Phase
Creativity phase	R1-6: No significant synergy	R1-6: No significant synergy	R2-5: Value flow can be improved by proposing innovative and creative ideas to minimise non-value adding activities	R1-6: No significant synergy	R1-6: No significant synergy	Creative ideas can be proposed to enhance value flow in order to minimise non-value adding activities at the creativity phase

(*continued*)

	Lean principle					
	Customer value	Value stream	Flow	Pull	Perfection	Synergy
Evaluation phase	R1-6: No significant synergy	R1-6: No significant synergy	R1-3, R5 and R6: Creative ideas proposed to enhance flow can be evaluated and most effective solutions can be selected at this phase	R1-6: No significant synergy	R1-6: No significant synergy	Creative ideas for flow enhancement can be evaluated and effective ideas can be selected at the evaluation phase
Development phase	R1-6: No significant synergy	R1-6: No significant synergy	R1-3: Cost benefit analysis of the selected flow development ideas can be conducted. Final flow development proposals and implementation plan can be developed at this phase	R1-6: No significant synergy	R1-6: No significant synergy	Value flow development proposals with implementation plans can be created at the development phase
Presentation phase	R1-3: This is an attempt to verify actual requirements of the client R4 and R6: Findings related to the client's value can be presented to the client and can get confirmed	R1-3: There is a synergy in attempting to verify value stream R4: Client can check whether the objectives are achieved or not R6: Findings can be presented to the client and get confirmed	R1-4 and R6: Flow improvement ideas can be presented to the client for verification and confirmation	R1-3: This is an attempt to verify the things pulled by the client R4 and R6: Findings related to the functional requirements pulled by the client can be presented to the client and can get verified	R1-4 and R6: The perfection expected by the client can be presented and get confirmed by the client	Findings of client's value, value stream mapping, creative ideas to enhance value flow, client pulled functional requirements and expected perfection can be presented, and get verified from the client at the Presentation Phase

(*continued*)

Table III.

Table III.

	Lean principle					
	Customer value	Value stream	Flow	Pull	Perfection	Synergy
Post-study phase	R1-6: No significant synergy	R1-6: No significant synergy	R1-6: No significant synergy	R1 and R3-6: There is a synergy between post-study phase and pull and hence can be mapped. It is important to pull the resources at the right time in right quantity and quality R5-6: Address any variations from what was pulled by the client during construction stage	R1 and R3: Continuous improvement is highly necessary at this phase R5: Continual focus on mitigating deficiencies and wastage is important R4 and R6: The perfection can be achieved by continuous review and improvement	New functional requirements and all resources must be pulled at the right time in right quantity and quality, while achieving perfection through continuous improvement at post-study phase
Synergy	Client Value can be specified, established and verified at pre-study, information and presentation phases, respectively	Value Stream mapping can be conducted and verified at the functional analysis and presentation phases, respectively	Value Flow enhancing activities can be created, evaluated, developed and verified at the creativity, evaluation, development and presentation phases, respectively	Functional requirements can be pulled, verified and ensured at the functional analysis, presentation and post-study phases, respectively	Perfection can be defined, established, verified and achieved at pre-study, information, presentation and post-study phases, respectively	Lean principles and VE job plan can be integrated to achieve value for client's money

extracted from the client's perception on value, project scope and expected perfection can be presented to the client and can get verified at the presentation phase. All respondents highlighted the importance of pulling functional requirements expected by the client during functional analysis phase. Moreover, four respondents stated that value stream mapping can be applied to identify value adding functional requirements of the project, while avoiding non-value adding requirements during this phase. At the presentation phase, client can compare the proposed functional requirements with expected requirements, and either confirm or amend the functional requirements as necessary. During the creativity phase, VE team can propose innovative and creative ideas to strengthen the value adding activities, while eliminating non-value adding activities stated in the project implementation and delivery plan and hence enhance the project value flow. The feasibility and viability of the creative ideas can be evaluated and most effective ideas can be selected at the evaluation phase. During the development phase, cost benefit analysis can be conducted for the selected ideas, and flow development proposals, strategies and implementation plans can be developed. The selected creative flow improvement ideas and development proposals can be presented to the client at the presentation phase for verification and confirmation. Any further changes to functional requirements after the value-study phase can be pulled by the client after ensuring them as value adding requirements. It is important to pull all necessary resources at the right time, in right quantity and quality during post-study phase. Continuous focus and review on mitigating construction process deficiencies and non-value adding activities while ensuring continuous improvement is highly essential for achieving perfection at this phase. The above findings confirm that there is a synergy between Lean principles and VE job plan and also agree with the findings of Shekari and Fallahian (2007) on possibility of integrating two concepts in manufacturing industry.

The literature review on the two concepts and the above empirical findings were subsequently used to develop a basis for LiVE concept. According to literature (refer Table I), both Lean and VE concepts are systematic approaches to enhance customer value through waste elimination and ensure value for money, respectively. Lean concept focuses on performance improvement, while VE concentrates on achieving essential functional requirements throughout the phases of VE job plan. Both concepts aim to reduce unnecessary costs, minimise wastes, optimise project quality, achieve perfection and ultimately deliver value for money.

According to the opinions of R1, R4 and R5, greater satisfaction of the client on the construction outcome would be a certain by integrating the concepts and therefore it is vital to integrate the concepts together to achieve allied benefits in construction projects. Further, R2 and R3 explained that as individual strategies, both concepts have its own strengths and weaknesses, which could be addressed by combining them together. This finding confirms the statements made by Cell and Arratia (2003), Wixson (2005) and Shekari and Fallahian (2007). According to R6, both of these strategies focus on enhancing the value. Hence, combining these two strategies could lead to a robust approach in enhancing the value of construction projects. Moreover, research findings presented in Table III reveal that there is a synergy between Lean principles and VE job plan and hence the concepts can be integrated together to achieve value for client's money.

Based on the literature review and empirical findings of Step I, the study proposed the LiVE concept with an initial definition as a systematic approach, which specify client's value, identify the value stream, make value flow without interruption, let the client pull functional requirements and pursue perfection during pre-study, value- study and post-study phases in VE job plan while reducing unnecessary costs and wastes, in order to enhance project performance and ultimately achieve value for client's money.

Subsequently, the study developed LiVE phases for LiVE concept based on the empirical findings of synergy between Lean principles and VE job plan. The research findings summarised in the last column in Table III were used to propose eight phases based on Lean and VE synergy as presented in Table IV.

Pre-study phase is renamed as value initiation phase, since the client's value, project scope and expected perfection is identified at this phase. The second phase, i.e. information phase is named as value establishment phase to reflect the establishment of project scope and client requirements to achieve client's value and perfection during the phase. Further, functional analysis, creativity, evaluation and development phases are reworded by adding the term value to better reflect the synergy. The seventh phase is renamed as value verification phase since the verification of identified client's value, value stream, value flow enhancement creative ideas, client pulled functional requirements and expected perfection are done at the presentation phase. The last phase is labelled as value achievement phase to reflect the final outcome of the process.

The proposed LiVE concept with eight phases was subsequently presented to the same experts for verification during Step II, which further explains below.

4.2 Step II: establish the LiVE concept with LiVE phases

Expert interviews with the same six respondents were conducted during Step II and the experts were requested to comment on and verify the completeness of the proposed LiVE concept with eight phases. During the interviews, R1 and R2 proposed to combine value initiation and value establishment phases together as initiation of value is the starting sub activity of establishment of value. Considering the above change, R2 suggested to revise the definition including the term "LiVE phases" instead of "pre-study, value-study and post-study phases in VE job plan". The definition, eight phases, and R1 and R2's suggestions were presented to other four respondents. They endorsed the suggested revisions and

Table IV.
Eight phases proposed based on Lean and VE synergy

Lean principle	VE phase	Lean integrated value engineering phase	Description of the phase
Customer value Perfection	Pre-study phase	Value initiation phase	Specify client's value, project scope and perfection
Customer value Perfection	Information phase	Value establishment phase	Establish project scope and client requirements to achieve client's value and perfection
Value steam pull	Functional analysis phase	Value functional analysis phase	Enhance client pulled functional requirements using value stream mapping
Flow	Creativity phase	Value creativity phase	Propose creative ideas to enhance value flow in order to minimise non-value adding activities
Flow	Evaluation phase	Value evaluation phase	Evaluate creative ideas for flow enhancement and select effective ideas
Flow	Development phase	Value development phase	Create value flow development proposals with implementation plans
Customer value Value steam Flow Pull Perfection	Presentation phase	Value verification phase	Present findings of client's value, value stream mapping, creative ideas to enhance value flow, client pulled functional requirements and expected perfection and get verified from the client
Pull Perfection	Post-study phase	Value achievement phase	Pull new functional requirements and all resources at the right time in right quantity and quality, while achieving perfection through continuous improvement

confirmed that the revised definition is comprehensive. The respondents further agreed with the proposed revised phases. R3, R4 and R6 requested to revise the wordings of the third phase to provide a better meaning and R6 further suggested to rename it as "value analysis of functional requirements phase". Based on the above feedback, the study identified seven LiVE phases and developed a definition for LiVE concept, which are explained in Section 5.

4.3 Step III: develop LiVE concept implementation approach

During the interviews, the experts were posed with Q2 and requested to identify an approach to be followed in implementing LiVE concept in construction projects. The respondents proposed a number of activities to be carried out during the seven LiVE phases. The activities proposed by the experts were analysed using code-based content analysis. The findings were used to develop LiVE implementation approach. Further, they were requested to identify the enablers and barriers allied with the implementation of LiVE approach. The outcome of this step is explained in Section 5.

5. LiVE concept and its implementation approach

The aim of this study was to investigate the synergy between Lean and VE concepts, and to develop a LiVE concept with implementation approach for construction industry. According to the empirical findings of Step I, it is evident that there is a strong synergy between Lean and VE concepts. The synergy between Lean principles and VE job plan was presented in Table III.

Having considered the feedback given by the respondents in Step II, the study proposed a novel concept, i.e. LiVE with seven phases; "Value establishment phase", "value analysis of functional requirements phase", "value creativity phase", "value evaluation phase", "value development phase", "value verification phase" and "value achievement phase". Further, LiVE concept can be defined as:

> a systematic approach, which specify client's value, identify the value stream, make value flow without interruption, let the client pull functional requirements and pursue perfection during LiVE phases, while reducing unnecessary costs and wastes, in order to enhance project performance and ultimately achieve value for client's money.

Subsequently, the findings of Step III were incorporated into the LiVE concept implementation approach. The LiVE approach was then presented to two subject matter experts representing industry and academia for validation. The first expert is a director in a construction organisation with over 25 years of experience in construction project management and has experience in implementing Lean and VE concepts in several large scale projects. The second expert is a senior academic in a university with over 20 years of research experience in the field of VE and waste management in construction industry. After referring the LiVE concept and implementation approach, the both experts confirmed that LiVE approach is comprehensive and captures the synergy between the concepts. They further stated that the approach is valid and can be effectively applied to the construction industry. The validated LiVE approach is presented in Table V.

The LiVE approach presented in Table V summarises the LiVE concept, description of each LiVE phase and activities to be followed by VE team during the seven implementation phases. Moreover, during Step III, the experts recognised, less awareness of the industry on the concepts, difficulties associated with team working, lack of industry experts in implementing the concepts, profit seeking attitude of consultant, difficulty in eliminating wastage in construction projects, lack of industry readiness and negative attitudes of employees to accept a novel value achieving strategy, time taken for implementation process, extra cost in implementing the concept, lack of technology and resources and lack

LiVE concept
LiVE is a systematic approach, which specify client's value, identify the value stream, make value flow without interruption, let the client pull functional requirements and pursue perfection during LiVE phases while reducing unnecessary costs and wastes, in order to enhance project performance and ultimately achieve value for client's money

LiVE phase	Description of the phase	LiVE implementation approach
Value establishment phase	Specify and establish project scope and client requirements to achieve client's value and perfection	Identify client's requirements and attitudes towards waste minimisation and value enhancement Specify and establish project objectives in client's perspective Specify and establish project scope Specify and establish the perfection evaluation criteria Develop data package with a special emphasis on information relevant to waste minimisation and value enhancement Determine team composition including experts in Lean and VE
Value analysis of functional requirements phase	Enhance client pulled functional requirements using value stream mapping	Pull functional requirements expected by the client Apply value stream mapping to define and classify value adding and non-value adding functions Eliminate avoidable non-value adding functions Compare cost to worth of functions to establish the best opportunities for improvement Refine the construction sequence and establish construction programme
Value creativity phase	Propose creative ideas to enhance value flow in order to minimise non-value adding activities	Encourage the team to come up with innovative ideas or concepts to enhance value flow with the aid of past experience and knowledge Discourage creativity inhibitors and take value added activities to a flow
Value evaluation phase	Evaluate creative ideas for flow enhancement and select effective ideas	Synthesise similar ideas or concepts for flow enhancement Appoint idea champions Gather data related to short and long term implications of these ideas and concepts List advantages and disadvantages of each value flow enhancement ideas or concepts Evaluate benefits and implications of proposed value flow enhancement ideas or concepts Select feasible ideas or concepts and smooth the flow by eliminating creativity inhibitors
Value development phase	Create value flow development proposals with implementation plans	Conduct Whole Life Costing and Cost Benefit Analysis for the highest ranked value flow enhancement ideas or concepts Compile a technical data package for each proposed idea or concept including best alternative materials, methods and tools Develop implementation plans including value flow proposal and implementation team Finalise recommendation
Value verification phase	Present findings of client's value, value stream mapping, creative ideas to enhance value flow, client pulled functional requirements and expected perfection and get verified from the client	Present findings of project scope, client pulled functional requirements, value flow enhancement concepts and ideas, implementation plan including value flow proposal, expected perfection and final recommendations to the Client Get the findings amend and/or verify by the Client and make final recommendations

Table V.
The LiVE approach

(*continued*)

Value achievement phase	Pull new functional requirements and all resources at the right time in right quantity and quality, while achieving perfection through continuous improvement	Implement the approved final recommendations while ensuring continuous improvement of value flow Ensure that all the required resources are available just in time to commence each activity Address any further client pulled functional requirements and value flow enhancement activities after ensuring its value addition Monitor progress, compare the outcome with the established perfection criteria and correct any deviations Conduct a post audit and record feedback for future benefit

Table V.

of commitment from top management, as the possible barriers in implementing LiVE approach. In order to overcome the barriers, the respondents proposed to strengthen the enablers such as appointing competent persons for the construction project tasks, conducting awareness and training programmes for the industry practitioners, introducing proper communication plans and channels among the construction industry stakeholders, including rewarding system for LiVE implementation in the contract and commitment from top management and the client.

By implementing the proposed novel LiVE approach, construction industry practitioners could be benefitted with reduced unnecessary costs and wastes associated with every stage of construction processes, optimised project functionality, enhanced project performance and thereby ultimate achievement of the best value for client's money. The LiVE approach can be further strengthened by identifying and incorporating appropriate Lean tools and techniques into seven LiVE phases.

6. Conclusions and recommendations

The dynamic nature of construction industry and its competitive and risk prone work environment have forced the firms to explore novel strategies to achieve best value for client's money. Although several value achieving concepts being utilised in construction industry, the researchers highlighted that VE and Lean supersede all the other concepts as they address the concept of Value in a greater extent. Further to literature, VE can leverage, accelerate and amplify efforts to implement Lean principles and practices in an organisation. In turn, Lean can enhance the effectiveness of VE efforts. Hence, integration of VE and Lean thinking could enhance the value in construction projects. However, there was a lack of research on the synergy between Lean and VE approaches for the construction industry. Hence, this study aimed to identify the synergy between two concepts and to develop LiVE approach for construction industry. A qualitative research approach with three steps was applied in attaining the research aim.

The study established that there is a strong synergy between Lean and VE concepts. It further introduced the novel LiVE concept to the theory, which is defined as "a systematic approach, which specify client's value, identify the value stream, make value flow without interruption, let the client pull functional requirements and pursue perfection during LiVE phases, while reducing unnecessary costs and wastes, in order to enhance project performance and ultimately achieve value for client's money". The study further identified seven LiVE phases as "value establishment phase", "value analysis of functional requirements phase", "value creativity phase", "value evaluation phase", "value development phase", "value verification phase" and "value achievement phase". The study finally developed LiVE approach to implement the concept efficiently and effectively. Moreover, possible barriers and enablers in implementing LiVE approach were identified during the expert interviews.

The LiVE approach can be used by the construction industry practitioners to reduce unnecessary costs and wastes associated with construction processes and enhance project performance. This novel approach ultimately optimises the project functionality and ensures the best value for client's money.

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Corresponding author
E.M.A.C. Ekanayake can be contacted at: anushikac@yahoo.com