POSITIONING THE CONSTRUCTION INDUSTRY IN NIGERIA FOR NATIONAL ECONOMIC GROWTH

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Forward

Economic growth has become a global concern as several economies are grappling contraction, resulting in growing unemployment rate, inflation and low productivity. Nigeri just coming out of recession and still requires the contribution of all sectors of the economy only for a rapid recovery but also to lay the foundation for a sustainable economic growth.

The construction industry represents a major source of economic activities providing infrastructural base for productivity and good quality of life, as well as generating opportunities for millions of unskilled, semiskilled and skilled workforce. It also genera income in both formal and informal sectors and has potentials for foreign exchange earnin from the trade in construction materials and export of professional services.

The conference brought together scholars, industry professionals/practitioners and senior publ service officials/administrators, to explore current developments and advances in the organization of the construction industry for effective contribution to national economic growt Original well researched and innovative contributions were presented and discussed in th conference.

The proceedings have indeed been through an unplanned long gestation period, due largely t the tardiness of the peer-review process of sifting the papers from the very many that featured i the conference. The good news however is that we now have them produced and are available t enhance understanding of the very wide range of issues pertaining to positioning th construction industry in Nigeria for national economic growth.

Welcome to an appreciation of the enormous potentials and challenges existing in Nigeria construction industry; as you go through the papers in the proceedings.

Prof. I. Mbamali

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Development of a Framework for Waste Reduction in Structural Design Phase of Construction Projects

A. Aka[1], F. Emuze[2], D. Das[3] and B. Awuzie[4]

Abstract

The absence of an effective framework for measuring and eradicating non-value adding activities (NVAA) in the structural design process (SDP) has led to waste that affect construction performance. This paper provides a lean informed framework that can be adopted by structural engineers to identify and reduce wastes in their practices. Lean informed frameworks based on tools such as Kanban, A3 problem-solving report, 5 Whys, Kaizen, and value stream mapping (VSM) were reviewed. The outcomes of the reviewed literature indicate that the aforementioned tools are common regarding the elimination of waste in the design and construction process. However, none of the tools has been used to reduce waste in the SDP. A subsequent careful appraisal of all the tools suggests that VSM is the most suitable tool that is capable of conceptualizing the problem under investigation. Therefore, VSM was used to develop a framework that can be adopted by structural engineers to identify and reduce waste in their practices. The applicability and usefulness of the proposed framework as it enables structural designers to perceive the various activities that could be trimmed in each phase of the SDP is supported by the results of the study, although the credibility of the framework is currently being examined by groups of consulting engineers located in Bloemfontein South Africa.

Keywords: *Construction, Design, Framework, Lean, Structure, Waste.*

Introduction

The structural design process (SDP) of a construction project entails a systematic means of investigating the stability, strength, and rigidity of a structure (Al Nageim *et. al*, 2010). Its main objective in a project is to produce a structure that is capable of withstanding all imposed loads without failure during its intended lifetime (Nelson *et al.*, 1988). The process is made up of five distinct phases that are full of non-value adding activities (NVAA) that constitute waste in projects (Melhado & Agopyan, 1996; Al-Aomar, 2012; Ko & Chung, 2014; Aka *et al.*, 2017).

Waste in this context has been described as any form of unnecessary work done and material loss that can increase production costs, whilst adding no value to the product itself (Koskela, 1992). Such unnecessary work done and material loss include waiting time, quality costs, lack of safety, rework, unnecessary transportation trips or long distances, improper management procedures, work not done, excessive vigilance, incomplete work, and poor constructability (Koskela, 1992). Studies by Womack and Jones (2003), Koskenvesa *et al.* (2010), Zoya-Kpamma and Adjei-Kumi (2011), Al-Aomar (2012) and Koskela *et al.* (2013) reveal that waste can also be defined as any activity that produces costs directly or indirectly and takes time, resources or requires storage, but does not add value or progress to a particular product.

The previously mentioned definitions indicate that the causes of waste in construction have been the subject of several studies (Li *et al.*, 2008; Mossman, 2009; Nagapan *et al.*, 2012; Koskela *et al.*, 2013). One main set of causes are the problems that are not detected in the design phase of projects (Zoya-Kpamma & Adjei-Kumi, 2011; Ko & Chung, 2014). Hence, the design phase is the most critical aspect of a project (AbdelSalam *et al.*, 2010; Koskela *et al.*, 2013). The phase is critical as it is in this phase that values are explored and expressed so that when it is well managed, waste and associated problems can be minimized in the construction phase (CP) (Li *et al.*, 2008; Ko & Chung, 2014). Despite its complexity, few researchers have investigated how a concept or framework can be promoted to reduce or eliminate waste in the design phase (Marzouk *et al.*, 2011; Ko & Chung 2014). Based on the opinions of the above-mentioned investigators on conceptual framework, researchers worldwide have investigated how lean thinking can be utilized to develop a framework for waste identification and reduction in projects (Melton, 2005; Rother & Shook, 2009; Ko & Chung, 2014). However, the reviewed literature indicates that a framework in the field of structural design practice is limited or non-existent. As a result, the broad purpose of this article is to put forward a framework for waste identification and reduction in SDP which will consequently enhance effective projects delivery in the built environment.

Value and Waste in the Design Phase of Projects

Notably, the concept of value has continued to defy any commonly accepted definition. Contemporary literature findings suggest that it has several meanings. For instance, Koskela (2000) refers to value as the fulfilment of customer requirements. While Garcia (2003) expresses value as a relation established between subject and object. In a study conducted by Menger (2007), it was further discovered that value is not inherent in goods, but certain importance that goods can acquire for the users. In contrast to value, non-value adding activities (NVAA) in the design phase of projects are the activities that are of no use but constitute waste in the process (Womack & Jones, 2003). Such activities can be classified into seven classical categories namely: transportation, defects/corrections, overproduction, over-processing, motion, inventory, and waiting time (Koskela, 1999; Womack & Jones, 2003; Simms, 2007; El-Kourd, 2009; AbdelSalam *et al.*, 2010).

Researchers have investigated how the above-mentioned construction waste can be reduced or eliminated through the design phase of a project (AbdelSalam *et al* 2010; Ko & Chung 2014). However, the findings in the reviewed literature indicate that attention is focused mainly on the architectural process (AP); aspect of the SDP is still unexplored. He[nce] the need for the lean framework that ca[n] adopted for waste identification and reduc[tion] in the structural design phase of projects.

The Lean Production Theory

Lean production theory had lim[ited] application in construction due to [the] perception that construction is comple[x and] different from manufacturing produc[tion] (Forbes & Ahmed, 2011). Other theories su[ch] as business process reengineering (BBR), a[nd] the constraints theories were of tremendo[us] applications (Green, 1999; Nave, 2002; Forb[es] & Ahmed, 2011). However, in the evolut[ion] of lean construction, Koskela in 1992 appl[ied] the concept to construction with a resear[ch] work. The production theory has develop[ed] into what is now known as [the] transformation-flow-value (TFV) (Kosk[ela] 1992). Since the discovery of this theory [in] 1992, the philosophy has been applied [to] eliminate waste in the design and [the] construction phases of projects. It is essen[tial] to know that lean thinking is a busin[ess] methodology that aims to provide a new w[ay] to contemplate how to organize hum[an] activities to deliver benefits and value to [the] society while eliminating waste (Womack *et al.*, 1990). The philosophy can be viewed mai[nly] in three perspectives to include le[an] production (LP), lean construction (LC), a[nd] lean design (LD).

Womack *et al.* (1990) originally define LP [as] means of utilizing half of human effort in t[he] factory, manufacturing space and engineer[ing] hours to develop a product within a sh[ort] time. This infers that LP requires keeping [...] less than half the needed inventory on site th[at] results in fewer defects, and produces greater and ever growing variety of produ[cts] (Womack *et al.*, 1990). Womack and Jo[nes] (1996) later improved on lean philosophy [by] proposing value, value stream, flow, pull/p[...] and perfection as the five basic principles [of] LP. Typical examples of the LP tools [for] waste identification and reduction inc[lude] VSM, 5 Whys, Kanban (pull systems), [...] problem solving report, and Kaizen (Kosk[...]

1997; Holweg, 2007; Liker & Michael, 2008). Koskela (1992) reveals that a growing number of organizations has implemented the Kanban. For instance, the Kanban were first adopted in material and component manufacturing, and later in the design and the construction phases of projects (Koskela, 1997).

Sacks and Goldin (2007) suggest that LC adopts the principles of LP to create a new way to manage construction projects. This denotes that LC has the same goal as LP, which is to meet customer needs in a better way while using less of every available resources (Koskela, 1992). Therefore, LC can be referred to as the application of LP principles and practices in the design and the construction phases of projects to maximize value and to reduce waste (Koskela, 1997; Ballard & Howell, 2003). From a research perspective, one of the typical examples of successful experience of the application of lean principles in projects can be observed in Brazilian construction industry (Conte & Gransberg, 2001). Conte and Gransberg (2001) implemented the five LP principles to over 20 construction companies in Brazil. The researchers concluded that application of lean thinking in construction will lead to waste reduction, and reduce the duration and the overall cost of projects. Similarly, Thomas *et al.* (2003) in their study proposed on how projects variability can be reduced so as to improve performance, and labour flow reliability for better productivity through the knowledge of the five lean principles and tools.

LD is the application of lean concepts to the design phase (DP) of a system (Czap, 2013; Stouffer, 2013). The system may be complex product or process (Czap, 2013; Stouffer, 2013). It is a way of designing production systems to minimize waste of materials, time, and effort to create the maximum possible value (Czap, 2013; Stouffer, 2013). Czap (2013) and Stouffer (2013) emphasize that one major goal of LD is to reduce waste and maximize value. Other goals are to improve the quality of the design and reduce the time to achieve the final solution. LD concept has been used in architecture, healthcare, product development, processes design, information technology systems, and even in modern businesses to create lean business models (Czap, 2013; Stouffer, 2013; Ries, 2011).

LD application is used in the form of principles and methods for managing the processes and the development of construction process (Jorgensen *et al.*, 2004). According to Czap (2013) and Stouffer (2013), conventional mass-production design focuses primarily on product functions and manufacturing costs; whereas LD systematically widens the design equations to include all factors that determine a product's success across its entire value stream and life-cycle. Stouffer (2013) and Ries (2011) emphasize that the most important determinants of projects are supposed to be workflow reliability and labour flow, but LD has changed the traditional view of construction as transformation, and embraces the concept of flow and value generation. It should be remembered that LD also shares the same objectives of LP and LC, e.g., cycle time reduction, elimination of waste, and variability reduction. To this end, continuous improvement, pull production control, and continuous flow have been the direction for the implementation of LD (Ries, 2011; Czap, 2013). This implies that LD is also using the same LP principles, and techniques that are originally developed by Womack *et al.* (1990) to reduce waste, increase productivity and effectiveness in the DP of a project. These principles are succinctly described in the next sub-sections.

To be succinct, the five lean principles proposed by Womack and Jones (2003) can be applied to the three phases of the project design (initiation, core design, and finalization) to eliminate all sources of waste (Marzouk *et al.*, 2011; Velarde *et al.*, 2009).

Conceptual View on How to Improve the Design Phase of Projects

In order to have clear knowledge of how LP theory can be adopted for improvement in the design phase of projects, it is essential to first understand how the philosophy is used for performance improvements in the manufacturing industry. A typical example of this is the Toyota's Production System (TPS) or the Toyota's Way (TW) (Forbes & Ahmed, 2011). The TPS represents an important foundation of lean construction and has emerged since the 1960s (Forbes & Ahmed, 2011). The TPS uses four elements, specifically the just-in-time (JIT) and the creative thinking to provide outstanding levels of production, high quality, and low costs (Forbes & Ahmed, 2011). Table 1 provides the summary of the four basic aspects of TPS and how lean thinking is applicable to each aspect.

In the four basic aspects of TPS concise in Table 1, the process (waste elimination) is the most applicable to the construction process (Forbes & Ahmed, 2011). The various process waste that are being eliminated in TW which are also applicable to the construction process are defects or corrections, overproduction, over-processing, transportation, inventory, motion, and waiting time (delay). Researchers worldwide have investigated how the above-stated wastes can be eliminated in the design and the construction phases of projects through the application of different lean tools such as A3 problem-solving report, VSM, 5 Whys, Kamban, and Kaizen (Huovila *et al.*, 1997; Nave, 2002; Schlueter & Thesseling, 2008; Sacks & Barak, 2008; Osmani, 2011; Marzouk *et al.*, 2011; Forbes & Ahmed, 2011; Ko & Chung, 2014). However, the findings in the reviewed literature indicate that attention is focused mainly on the CP of projects. The design phase has not been explored. This denotes that as at the time this review was done, none of the above-listed tools has been adequately adopted for waste identification and reduction in the structural design phase of projects.

Perhaps, the limited exploration of the tools required for waste elimination in the design phases of project is because researchers often find it difficult to decide on the tool to adopt (Nave, 2002). To overcome this dilemma, Nave (2002) points that researchers need compare the strengths and weaknesses of various tools. Nave (2002) is of the view the tool with the less weakness, and of m benefits in terms of waste identification reduction over others should be conside The strengths and the weaknesses of the tools highlighted above are illustrated in Ta 2.

The reviewed literature indicates that V has greater benefits over many other l tools as it can be used to analyse virtually the seven forms of waste in a process (Ro & Shook, 1998; Nielsen, 2008; Belova, 2 Mossman, 2009). VSM also enables investigator to clearly see any hidden prob and the sources of the problem in a sys (Mossman, 2009; Rother & Shook, 1 Nielsen, 2008). Based on these benefits VSM over other lean tools considered in study, the researchers were of the opinion the tool might be suitable or less challeng for waste identification and reduction in SDP. Collaborating with the opinion of researchers, Rother and Shook (2 observes that VSM can be adopted investigators to clearly understand the cu flow of work in an organization, map areas that require improvements, and plan how the areas can be improved Rother Shook (2009). Based on the observation Rother and Shook (2009) on VSM, atte have not been made by researchers investigate how the tool can be adopted waste reduction in the field of the struc design practice.

The decision to use VSM in this corroborate the previous work of Ko Chung (2014) that used the tool to deve framework for the elimination of waste architectural design process. Ko and ((2014) conclude that VSM is a suitab for waste identification and reduction design phase of projects. Premised on a explanations, VSM was used to devel proposed framework in this study.

Table 1: A representation of lean thinking in Toyota Way

Toyota Foundations	Principles
Problem solving (continuous improvement and learning)	Continual organizational learning; View the situation first hand to thoroughly understand it; Make decisions slowly by consensus (consider all options and Implement rapidly)
People and partners (respect, challenge, and grow them)	Grow leaders who live the philosophy respect, develop, and challenge people and teams; Respect, challenge and help suppliers
Process (eliminate waste)	Create process 'flow' to reveal problems; Use pull system to avoid overproduction; Level out workload; Stop when there is a quality problem; Standardize tasks for continuous improvement; Use visual control (transparency); Use only reliable and tested technology
Philosophy (long-term thinking)	Base management decisions on a long-term philosophy, even at the expense of short-term financial goals

(Forbes & Ahmed, 2011: 50)

Table 2: Benefits and limitations of some of the applicable lean tools in projects

Lean tools	Benefits	Limitations/weaknesses
Kanban	Kanban enables a process to be streamlined which enables a problem in the system to be resolved quickly. It also allows materials to always be available to meet production demands	On several occasions, Kanban can cause a potential loss of sale. Also, Kanban can only be effective if it is adequately monitored in a system, and may be difficult for an observer to realize the root cause of a problem in a process where it is applied.
The A3 problem-solving report	A3 problem-solving report enables a process to be transparent and comprehensible in a manner that creates adequate thinking and learning. Also, the tool does not require long hours of specialized training	Any form of interruptions in A3 process can create unnecessary delay in a system. Also, A3 problem-solving efforts often fail in implementation in a process.
The 5 Whys	It is simple to use and can be adopted easily by the investigators without the need for any form of training	It simplicity can make investigators to wrongly apply it in a system, and ignorantly arrive at the wrong conclusion in the system.
Kaizen	Kaizen is a lean tool that can be implemented in many ways. It is largely self-motivated as it is driven by individual input and execution	One main weakness of Kaizen is that it can only bring improvement in a system when people are willing and ready to make suggestions.
VSM	VSM is the only lean tool that can be used to identify overproduction, waiting, transportation, inappropriate processing, unnecessary inventory, unnecessary movement, and defects in a process. Therefore, it is the only lean tool that can be used to identify the root causes of the seven forms of waste in a process/product design	VSM cannot be used to adequately understand how the future state of a process in which it is applied should look like. Hence, perfection in adoption of VSM in a system solely depends on the skill of the user.

(Sources: Ohno, 1988; Krafcik, 1988; Shingo, 1989; Cheser, 1994; Cane, 1996; Barnes, 1996; Rother & Shook, 1998; 1999; Yamada, 2000; Sproull, 2001; Drickhamer, 2005; Jimmerson *et al.*, 2005; Liker & Morgan, 2006; Fantoni *et al.*, 2006; Ghosh & Sobek, 2006; Holweg, 2007; Sobek & Smalley, 2008; Nielsen, 2008; Belova, 2008; Hoppmann, 2009; Mossman, 2009; Chuck, 2013)

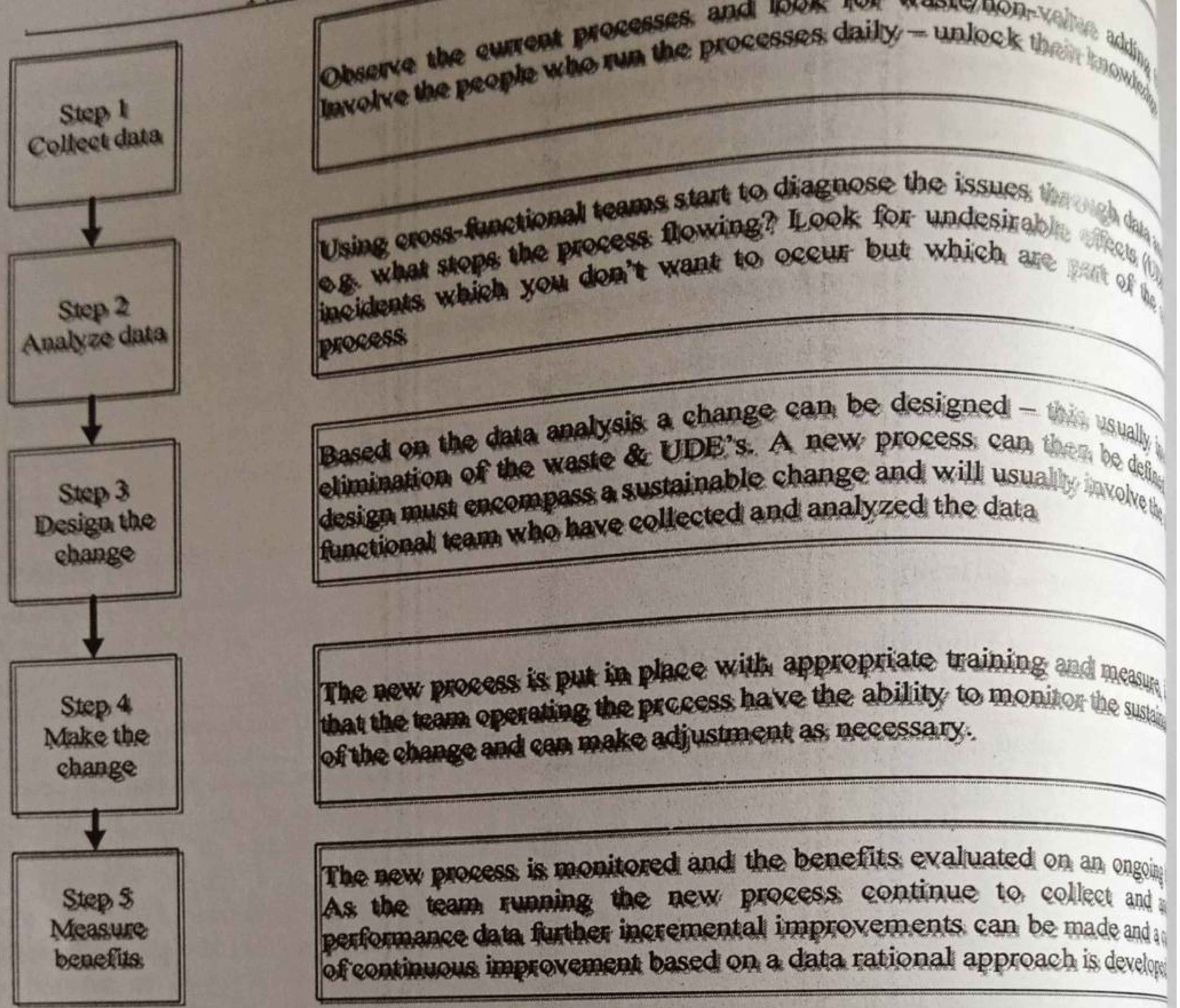

Figure 1: A Lean concept for waste identification and reduction in projects
Source: Melton (2005)

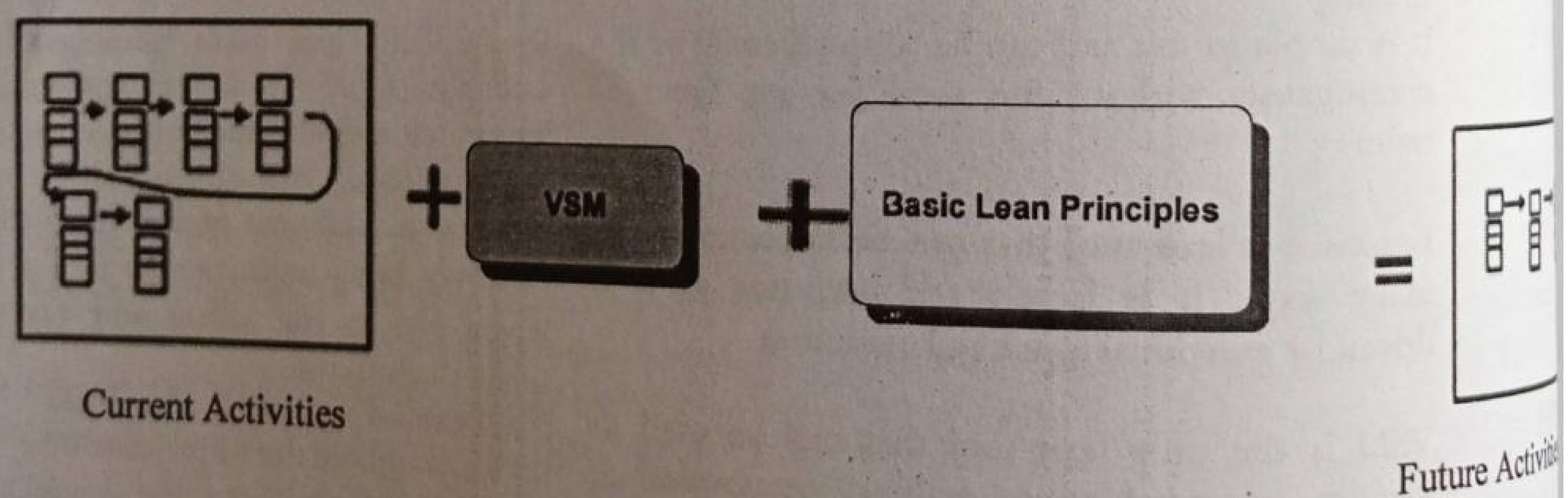

Figure 2: A value stream mapping framework for waste identification in an organization process (Adapted from Rother & Shook, 2009)

The Conceptual Framework

According to Milles and Huberman (1984), a conceptual framework is the current version of the researcher's map of the phenomenon under investigation. It provides a theoretical overview of a researcher's proposed study and order within the research process (Robson, 2011). Jabareen (2008) contends that the main functions or objectives of a conceptual framework is to help a researcher refine research goals, develop a realistic or relevant research problem and questions, select appropriate methods, and identify the prospective validity threats that may come in the conclusion section of the research. Miles and Huberman (1994), and Robson (2011) add that a good conceptual framework is expected to be constructed, as it

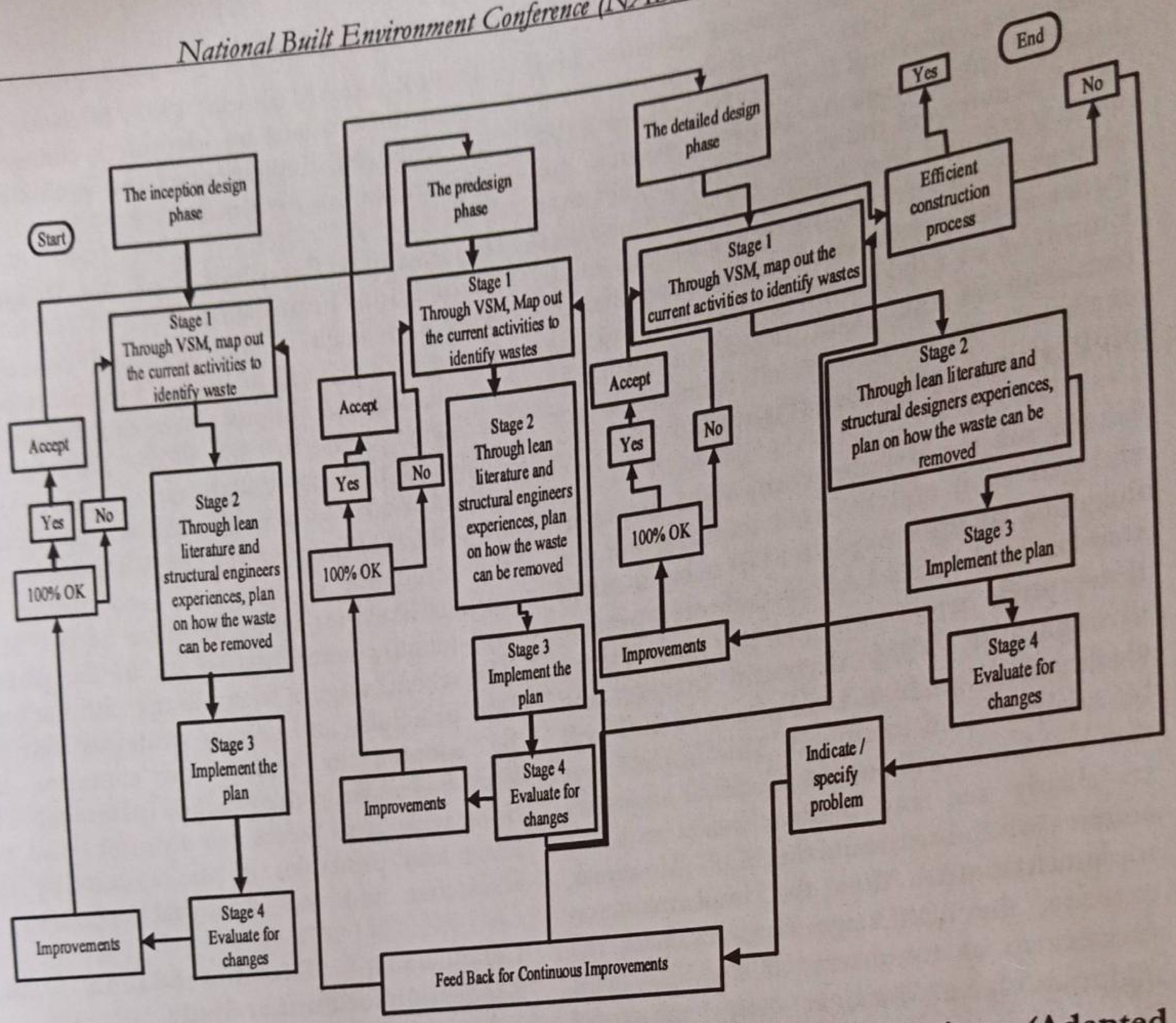

Figure 3: A conceptual framework for structural design process in projects (Adapted from Melton, 2005: 667; Rother & Shook, 2009)

a visual or written product that explains graphically or in a narrative form the key factors or variables to be studied, and the presumed relationships among the variables.

Based on the opinions of Miles and Huberman (1994), Jabareen (2008) and Robson (2011) on conceptual framework, Melton (2005) developed a lean framework for waste identification and reduction in projects (Figure 1).

According to Melton (2005), the procedures for waste identification and reduction in the conceptual framework can be summarized as:

- Document the current process performance;
- Define value and then eliminate waste;
- Identify undesirable effects and determine their root cause in order to find the real problem;
- Solve the problem and re-design the process, and
- Test and demonstrate that value is now flowing to the customer of that process.

Rother and Shook (2009) also develop a conceptual framework for waste identification and reduction in an organization process. Rother and Shook (2009) developed the framework through the application of a VSM tool (Figure 2).

In the conceptual framework, Rother & Shook (2009) content that VSM can be adopted by an organization manager to clearly understand the current flow of activities, and map out areas that require improvements. Thereafter, plan on how some of the basic lean principles can be used to reduce the NVA activities in the system. This implies that with VSM and lean principles, the four-stage workshop procedure for value identification in the initiation phase of design proposed by Emmit *et al.* (2005) in Figure 1 may not be necessary in the SDP. Based on all these explanations, a conceptual framework for SDP is hereby proposed (Figure 3).

In the proposed framework, VSM (a paper-and-pen tool) will be used to bring out the diagrams of the complete SDP using a set of standardized icons such as dedicated process flow, push arrow and manual info. Hence through the VSM diagrams (maps), any weakness or waste in each phase of SDP will be analyzed and identified. This implies that the VSM tool will enable structural engineers to clearly see any hidden waste and the sources of the waste in the SDP (Mossman, mplementation). After the implementation exercise, the next stage is to evaluate the process so as to observe if the new plans adopted have brought any substantial improvement in each phase of the SDP (evaluation). This implies that with notable improvements in the first phase of the SDP (IDP) after the adoption of the new strategies and some lean principles, the engineers are to move to the next phase (PDP) and repeat the exercise (mapping, planning, implementation and evaluation (MPIE)), and subsequently, to the last phase (DDP).

However, if the outcome in the IDP is not satisfactory after the evaluation process, the overall procedures (MPIE) will be repeated by the engineers until adequate improvements have been achieved. Based on these improvements, the engineers can then, proceed to the next phase, and afterward, to the last phase. Hence, the actuality/practicality of the proposed framework in the IDP, the PDP, and the DDP is currently being examined by five different consulting engineers in Bloemfontein, South Africa.

2009; Rother & Shook, 1998; Nielsen, 20[...] Once these waste are identified, changes [...] be proposed, implemented and evaluated [...] continuous improvements.

Operational Perspective of the Propo[...] Conceptual Framework

The first stage in the proposed concep[...] framework present in Figure 3 in this pape[...] to establish the various waste and their ca[...] in each phase of the SDP. This can [...] achieved through collaborative efforts o[...] group of structural engineers, and applica[...] of VSM tool (mapping). The VSM will ena[...] the structural engineers to see clearly [...] various activities in each phase of the S[...] and identify where waste are in the pha[...] The second stage is to come up with the b[...] lean principles and certain strategies that [...] be adopted to reduce or eliminate [...] identified waste in the practice (planning). [...] third stage is to effect the strategies and [...] basic lean principles in the system by [...] researcher and the structural engineers

Conclusions, Recommendation [...] Suggestion for Further Study

Based on the reviewed literature, it can [...] concluded that the application of [...] concepts in the built environment for w[...] elimination agenda started in 1992. Therea[...] lean concept has been extensively adopted [...] waste identification and reduction in [...] design and construction phases of proj[...] However, the philosophy has not [...] adequately adopted in the design ph[...] Among the well-known lean tools, the VS[...] advocated for the development of [...] proposed framework in this paper. This p[...] concludes that waste in the SDP can [...] reduced through the application of VSM. [...] of the benefits of using VSM is that it ca[...] used to identify overproduction, wai[...] transportation, inappropriate process[...] unnecessary inventory, unneces[...] movement, and defects/corrections i[...] process. Hence, VSM is the only lean tool [...] can be used to identify the root causes of [...] classic seven forms of waste in SDP proces[...]

is research recommends that the proposed nework developed with VSM and the five n principles in this paper should be adopted the structural design team for waste ntification and reduction during SDP. owever, it has been observed in the erature that the proficiency of the future te VSM depends on the skill of the erators. Therefore, for proficient outcomes the inception, predesign and detailed design ases of SDP, a more compressive VSM ftware that is independent of the skill or ility of the operators should be investigated developed by future researchers. This is sential as it may further enhance waste lentification and reduction in SDP and the uilt environment at large.

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