

An initial evaluation of a method for adopting kaizen events in the construction sector

Evaluación inicial de un método para adoptar eventos kaizen en el sector de la construcción

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Abstract

Currently, construction companies have shown a need to adopt process improvement systems in order to function competitively in the market. However, civil construction, compared to the manufacturing, still has deficiencies relating to the incorporation of new improvement systems. Thus, the use of Kaizen Events (KE) is one of the main mechanisms used to perfect processes during the production (execution) phase of a product, ensuring enhanced performance and added value to the client. The present research sought to evaluate a method for adopting KE in the construction sector. The data-gathering tools used were a questionnaire and a focus group where academics and/or experts who fit a specific profile participated. A methodological strategy for the development of the work was adopted under the approach of Design Science Research (DSR) and the theoretical referential was developed from a Systematic Literature Review (SLR). Improvements were made to the method to improve its applicability and functionality in real life scenarios using the results obtained. Accordingly, the results show horizons for future research on KE in civil construction.

Keywords: Kaizen events, continuous improvement, process improvement, lean thinking, construction sector

Resumen

Actualmente, las empresas de construcción han demostrado la necesidad de adoptar sistemas de mejora de procesos para establecerse competitivamente en el mercado. Sin embargo, la construcción civil, en comparación con la manufactura, aún presenta deficiencias relacionadas con la adopción de nuevos sistemas de mejora continua. Es así que los Eventos Kaizen (EK) es uno de los principales mecanismos para perfeccionar los procesos durante la fase de producción (ejecución) de un producto, asegurando un mejor desempeño y agregando valor al cliente. La presente investigación tuvo como objetivo la evaluación de un método para adoptar EK en el sector de la construcción. La recolección de datos se realizó con un cuestionario (43 personas) y un grupo focal (6 personas) donde participaron académicos y/o expertos quienes cumplieran un perfil determinado. Para el desarrollo del trabajo se adoptó una estrategia metodológica regida por la Investigación Basada en el Diseño (del inglés Design Science Research, DSR), y el referencial teórico fue desarrollado a partir de una Revisión Sistemática de Literatura (RSL). A través de los resultados obtenidos, se realizaron mejoras del método para lograr su aplicabilidad y funcionalidad a un caso real. En consecuencia, los resultados muestran horizontes para futuras investigaciones sobre los EK en la construcción civil.

Palabras clave: Eventos kaizen, mejora continua, mejora de procesos, pensamiento lean, sector de la construcción

1. Introduction

Over the last few decades, the challenge for companies to maintain considerable competitiveness in the market and to increase their profits has intensified. In response to these challenges, in the 1960s and 1970s, automotive industries in Japan began applying new mechanisms for planning, controlling and optimizing processes (Sheridan, 1997a). One of these mechanisms is the use of Kaizen events (KE), or focused and structured improvement projects that use a dedicated cross-functional team to improve a targeted work area with specific goals in

an accelerated time-frame (Letens et al., 2006). Significant evidence suggests that KE have become increasingly popular in recent years as a method of rapidly introducing improvements (Farris et al, 2008). In particular, Kaizen events have been associated with the implementation of Lean Production (Womack et al., 1990). However, the majority of KE publications are focused on anecdotal results from companies that have implemented KE (Sheridan, 1997a and Cuscela, 1998) and untested design recommendations from individuals and organizations that aim to facilitate KE's implementation (Farris et al, 2008). In fact, KE has been rarely used and poorly studied in the construction industry. Nevertheless, there are some exceptions such as the use of KE to incorporate, control and improve processes through tools along with the concepts of Lean Thinking in modular house construction (James et al., 2012; Dentz et al., 2009). In contrast, Shingo (1987, 2010) presents a scientific model for the implementation of process improvements called the Scientific Thinking Mechanism (STM). STM is a sequence

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consisting of five main stages that involve philosophies and techniques that lead to a result represented by the implementation of the participant's interventions (Shingo, 1987, 2010).

Therefore, a comprehensive method for the adoption of KE in the construction sector is still required to address the question of "How can Kaizen events be incorporated in the construction industry?" The data collection procedures for evaluating the proposed method were a semi-structured questionnaire and a synchronous focus group. 43 people responded to the questionnaire and 6 people joined the focus group. These participants fit a specific profile as they were either academics and/or construction industry experts. Therefore, the results were analyzed and synthesized in order to optimize the method's functionality and applicability during construction. Accordingly, directions for future research are discussed.

2. Literature review

2.1 Kaizen events (KE)

The term "Kaizen" is a combination of two Japanese words literally translated as "kai", meaning change, and "zen," meaning good (iSixSigma LLC, 2005). The most popular meaning is the continual and incremental improvement of all company aspects (Imai, 1986). The continuous improvement of processes is one of the principles that encapsulates the essence of the Toyota Production System (TPS) (Shingo, 1987). One way of adopting Kaizen in organizations is through the use of KE as a structured improvement mechanism (Melnyk et al., 1998).

A KE is a short-term project focused on a specific process or set of activities, such as the work flow within a specific work center (Melnyk et al., 1998). Kirby & Greene (2003) describe KE as a focused improvement event during which a cross-functional team spends several days (usually one week or less) analyzing and implementing improvements in a specific work area. These team members apply low-cost problem-solving tools and techniques to swiftly plan and, often, to implement improvements in a target work area (Figure 1). Hence, KE's focus is on using human knowledge and creativity through the application of a systematic problem-solving methodology along with structured process tools (Bicheno, 2001).

In addition, a KE includes typical activities such as training, documenting current processes, identifying opportunities for improvement, implementing and evaluating changes, presenting results to management, and developing an action plan for future improvements (Melnyk et al., 1998). Other terms frequently used in the literature to exemplify the KE are "Kaizen blitz" (Cuscela, 1998); "rapid Kaizen" (Melnyk et al, 1998) "breakthrough Kaizen"; "Kaizen workshops" (Sheridan, 1997a); "short cycle Kaizen" (Heard, 1997, 1998); "rapid improvement event" and "accelerated improvement workshop" (Melnyk et al, 1998). Since the mid-1990s, research related to KE has increased. However, there is evidence that the Toyota Company, through its TPS, has used rapid-change projects similar to KE with its suppliers since 1970s. (Sheridan, 1997b). In the context of the construction industry, there are some big obstacles to using this mechanism as the use of KE is usually restricted to manufacturing, an industry with some notable differences from the construction industry (Koskela, 2000; Thomassen, 2004).

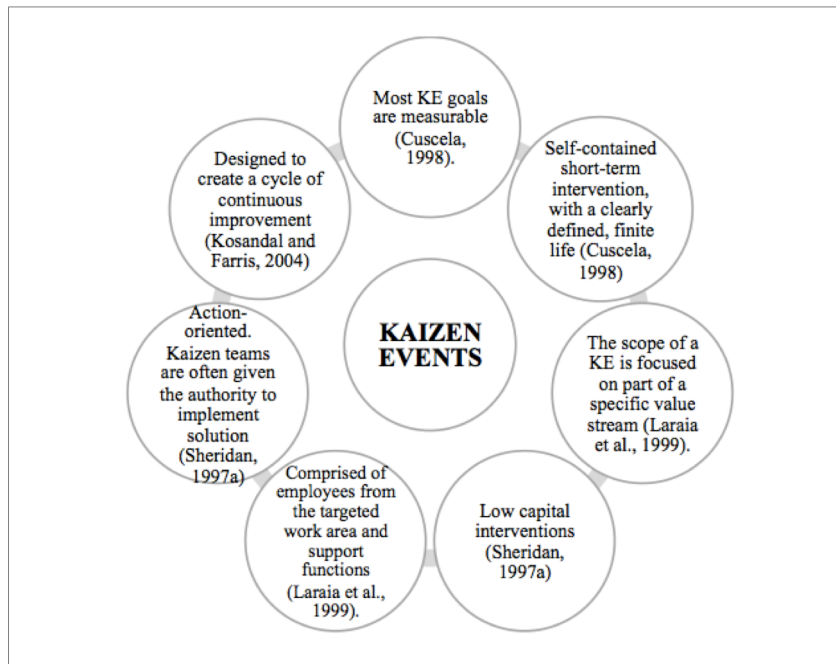


Figure 1. Seven characteristics that distinguish KE from other process improvement approaches.
Source: Melnyk et al. (1998)

2.2 The Scientific Thinking Mechanism (STM)

In a continuous improvement context, a scientific approach based on the TPS is the Scientific Thinking Mechanism (STM). STM is proposed for (i) the identification of problems and the analysis of their root cause, and (ii) the development and implementation of improvements in an organization (Shingo, 1987). Shingo (1987, 1990, 2010) describes the STM as having one preliminary and four main phases.

- (a) **Preliminary phase:** This phase is based on the idea that, when processes are analyzed in batches, their complexities linked to a process can be reduced to manageable elements. Thereby, many problems with current processes will be easier to identify.
- (b) **Problem identification phase:** Continuous improvement should only happen after the participants understand the nature of the identified problem. Subsequently, the solution to a problem follows three phases: finding the problem, clarifying it and finding its root cause.
- (c) **Phase of basic approaches to improvements:** Qualitative rather than quantitative aspects are emphasized. In other words, the participants must understand the facts in detail, think about the principles inherent to those facts and classify them into categories. Thus, companies must analyze the production system from procedural and operational perspectives.

- (d) **Realization phase of improvements plans:** Plans to improve processes should be understood and developed based on both scientific and creative criteria. Therefore, it is recommended not to criticize any idea proposed by the participants nor to attack trivial ideas, but to instead generate as many ideas as possible and, then, associate them.
- (e) **Phase of translating improvements plans to reality:** This last phase encourages the implementation of improvement proposals. It is inevitable that objections will arise from the participants during the implementation of these proposals. Nevertheless, participants must be able to discern which proposals truly add value and improve the targeted process.

3. Research design

3.1 Epistemological approach

This study is framed as an application of Design Science Research (DSR), in which all or part of the investigated phenomenon can be created as opposed to naturally occurring. It can be better explained by dividing it into the following phases (Kasanen et al., 1993; Lukka, 2003).

- (i) Finding a practically relevant problem, which also has the potential for theoretical contribution;
- (ii) Obtaining a deep understanding of the topic area that is both practical and theoretical;

- (iii) Innovating a possible solution and developing a problem-solving structure, which also has the potential for theoretical contribution;
- (iv) Implementing the solution and proving its practical applicability;
- (v) Examining the scope of the solution's applicability and
- (vi) Identifying and analyzing the theoretical contribution.

Table 1 shows the four phases that comprise research delineation. In phase (i) the problem is defined with practical relevance. In the phase (ii), a systematic literature review

(SLR) is conducted in order to establish an adequate theoretical foundation and to identify knowledge gaps that needs to be methodically studied. Thus, through the STM and the theoretical reference of the SLR, a method was constructed and outlined in phase (iii). Despite the fact that STM was conceived in the manufacturing industry, this mechanism was adapted for the construction sector given the many differences between the two industries. Finally, in phase (iv) the method was tested through the use of data-gathering tools (questionnaire and focus group). After phase (iv), the method can be refined and can prove its applicability in a real life scenario during the remaining DSR phases. However, those are not included in this paper.

Table 1. Research delineation. Source: Self-Elaboration

The process of a constructive research (Kasanen et al., 1993; Lukka, 2003):	Application of processes to construct the method	
(i) Find a practically relevant problem, which also has the potential for theoretical contribution.	How can KE be incorporated in construction companies?	
(ii) Obtain a deep understanding of the topic area both practically and theoretically.	Systematic Review of Literature, Toyota production System, Lean Thinking, Kaizen and Kaizen Events	
(iii) Innovate a possible solution and develop a problem-solving structure with the potential for theoretical contribution.	Method construction (Figure 2)	
(iv) Implement the solution and test its effectiveness.	Design and application of the questionnaire	Design and application of the Focus Group

3.2 Method for adopting Kaizen Events in the construction sector

A method was designed to orient and systematize continuous process improvement in construction companies (Figure 2). This method (flowchart) was divided into five stages and each of these stages has a chart that lists the tools and concepts that facilitate understanding and the applicability of the method.

• **Stage Zero (Pre-event):**

In this stage, actions are taken to recruit, instruct and motivate staff for the KE. Basically, in the context of Lean Thinking, it is important to achieve process stability before starting the improvement process as it facilitates the detection of problems and waste (Smalley, 2005).

This requirement can be accomplished through the use of different tools and concepts, such as the value-stream mapping (VSM), Flow Line (FL), 4M and so on (Bulhões and Formoso, 2004; Gallardo et al., 2014; Olivieri, 2016). Then, participants are given a brief introduction about the different Lean Thinking tools and concepts that could be used in the improvement process. Subsequently, the remaining stages of the method are scheduled and communicated to selected participants (Kaizen team).

• **Stage One (Problems identification):**

The leader of the Kaizen team offers incentives to apply the lean concepts and tools learned. This stage begins by observing and analyzing the current process, through

direct observation (going to the workplace) and/or using tools (VSM, FL, and so on.). Managers (field engineer, safety engineer etc.) can help Kaizen teams by identifying areas in need of improvement (bottleneck areas).

Consequently, the waste identified in the process should be defined according to the type of Muda¹. Moreover, this stage has two levels that are used to categorize manpower:

- (i) **Strategic Level:** managers, project coordinators, supervisors, etc.
- (ii) **Organizational Level:** operators, laborers, foremen, field engineers, etc.

• **Stage Two (Process Improvement Proposals):**

Solutions to problems are proposed through technical (equipment, communications, layouts and so on) and/or creative processes (brainstorming, workshops, among others). Then, proposals are synthesized, quantified and categorized so that a critical analysis of them can be performed in order to obtain an adequate solution (Shingo, 2010). Furthermore, it is important to emphasize that the solution should be aligned with the participants' know-how, economic viability and Lean Thinking principles.

• **Stage Three (Implementation)**

Later, performance metrics are proposed to assess solution progress and efficiency. These metrics can be quantitative or qualitative, depending on the improvement goal. It is possible that the KE is not completed due to external or internal process aspects. In that case, the leader of Kaizen team should reschedule and communicate the rescheduled event as soon as possible. Final metrics should be documented, which will demonstrate if the problem was mitigated or eliminated. Finally, good practices should be registered and shown to participants.

• **Stage Four (Post-event)**

Efforts are taken to analyze and learn the best practices achieved during the KE through graphics, spreadsheets, among other possibilities. Thus, a number of improvement opportunities are likely to be identified, focusing on the larger negative gaps identified during the KE, which should be planned and structured into future Kaizen events.

3.3 Design of the questionnaire and focus group

A semi-structured questionnaire (Naoum, 2007) and synchronous focus group (Stewart and Shamdasani, 2014) were constructed by considering the literature related to the use of KE in the manufacturing industry and the divergences between this industry and construction sector.

These data gathering-tools were validated by 2 experts² and 4 academics³ in the area of Lean Thinking. In this case, some authors (Cortes et al., 2011; Hallowell & Gambatese, 2010) argue that, according to the most recent applications related to construction management, the average number of participants should be 12, with a minimum of 5. These 6 participants evaluated the consistency, clarity, relevance, adequacy, structure, knowledge and content of the questions. Subsequently, a pilot test (preliminary questionnaire) was conducted in which the questionnaire was applied to 20 experts and academics who work in areas related to construction project management.

The preliminary questionnaire basically helped to evaluate the response time, the use of the virtual platform and the types of questions (open or closed). Then, the questionnaire was modified (final questionnaire) and divided into 4 sections, with a total of 26 questions: 3 questions related to the construction sector (Section A), 3 questions regarding the basic concepts of Lean Thinking (Section B), 6 questions related to understanding the KE method (Section C), 10 questions regarding the consistency of the method (Section D) and, finally, 4 questions related to the consistency and comprehension of the questionnaire. Of these 26 questions, 16 (Sections C and D) were closed questions (Naoum, 2007) that should be answered on a Likert scale, with values between 1 and 5 (Table 2).

Likewise, the focus group was given five questions related to the use of the method in a hypothetical improvement process which was explained in a five minutes video conference before beginning the activity. This hypothetical improvement process was limited to the execution of an activity for the construction of a residential building. The 5 questions were divided into opening, introductory, transitional, key and closing questions. This focus group was managed via video conference (Zoom software) and lasted approximately 45 minutes.

¹ Muda is a Japanese word meaning waste, which refers to all activities that do not add value to the final product. There are 7 types of Mudas recognized in TPS: transport, inventory, motion, waiting, over-processing, overproductions and defects (Monden, 1998)

² Expert: person who has sufficient professional experience (project manager, field engineering, among others).

³ Academic: person who is dedicated to teaching, linked to an educational institution, researcher and so on.



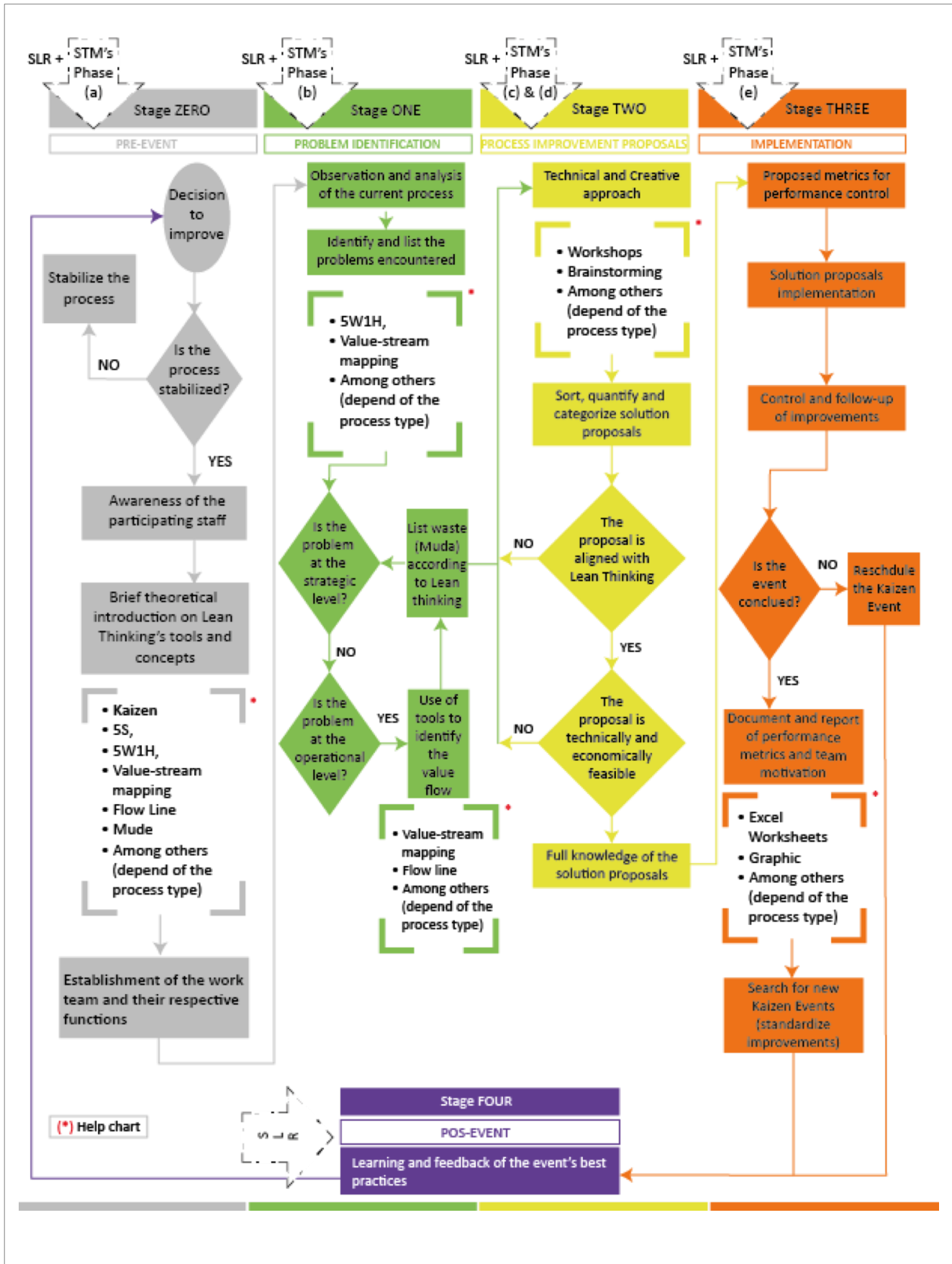


Figure 2. Method for adopting Kaizen events in the construction sector. Source: Self-Elaboration

Table 2. Scale for final questionnaire answers. Source: Self-Elaboration

1	2	3	4	5
Totally disagree	Disagree	Neither agree nor disagree	Agree	Totally agree

3.4 Data collection process

The final questionnaire was managed by Google Forms. It was sent to 43 experts and academics in Lima, Peru. Then, from these 43 participants, 4 experts and academics were selected to participate in the focus group. The objective of the data collection tools along with the limitations of the method were briefly explained in a virtual letter. Likewise, participants were prompted to consider their level of experience, according to their professional profile (Hallowell & Gambatese, 2010; Cortes et al., 2011). Suitable candidates chosen to answer the final questionnaire and participate in the focus group met one or both of the following requirements:

- (i) Experts with least 2 years of experience in the construction sector and a basic knowledge of Lean Thinking tools.
- (ii) Academics who have authored studies related to construction project management.

3.5 Information analysis and validation

The statistical validation of the questionnaire sections was performed by calculating the Cronbach Alpha Index (ACI) to determine the internal consistency of the questions. The ACI value was computed through the "psych" package contained in R Statistic software. This index allows one to evaluate the extent to which the items (questions) in a data collection instrument are correlated. When the ACI is greater than or equal to 0.70, the dimension is considered important and greater. When the ACI is greater than 0.90, there is internal redundancy between the items of the questionnaire (Streiner, 2003).

4. Results

4.1 Description of the sample

In total, 29 participants completed the questionnaire, representing a 67.44% participation rate based on the total sample (n=43). Of those, 51.7% were answered by experts, 3.5% by academics and 44.8% were answered by professional who were both academics and experts. All participants of the focus group were experts and academics who participated remotely via video conference.

4.2 Validation of the instrument

The statistical validation of the questionnaire's reliability was performed by calculating the ACI. This analysis primarily considered sections C and D (16 questions) of the final questionnaire. As a result, the IAC score was $\alpha = 0.771$ which allowed for conjecture suggesting that this instrument (the final questionnaire) was acceptably reliable in the context where it was applied.

4.3 Final Questionnaire

From the results of Section A, 55% believed that the construction sector has the tools needed to improve processes, compared to 45% who said no. For the analysis of the remaining questions, the Cano et al. (2015) classification of master factors was used. Hence, it was found that there were 3 important factors that obstruct process improvement in the construction sector: People (65.6%), Organizational Structure (79.4%), External Management and Value Chain (62.1%) and Externalities (89.7%). In addition, the lack of education and lack of continuous learning from good practices and cultural transformation are key points that also impede process improvement in the construction industry.

According to the results of Section B, all participants were familiar with Lean Thinking. However, some did not know its main objective or how it is defined in different contexts. Some participants listed a number of TPS and Lean Construction tools such as the VSM, 5S, FL, Batching Planning, Constraint analysis, Last Planner System, Balance Charts and performance metrics. As a consequence, the tools listed above demonstrate that most participants knew key concepts and their application, which helped them to understand the proposed method.

In Section C, more than 70% agreed or totally agreed that their knowledge of the Lean Thinking tools was sufficient for comprehending the method's purpose. Moreover, the results showed that the terms used to describe the method step-by-step were suitable and that the procedures (flowchart boxes) successfully showed the order of and relationships between each step of the method. The high percentage of "Neutral" responses was related to the clarity of the stages' purposes in the method and the opinion about the colors used to specify each stage.



In Section D, more than half of the participants considered that the method could not be applied over a one to two week period. Also, more than 70% considered that the initial introduction to Lean Thinking tools contributes to understanding the main objective and the flow of each stage, gauging participant commitment and the synergy between cross-functional groups, assessing the possibility of monitoring improvements in processes through metrics and motivating the participants before, during and after the KE. In contrast, a high percentage of "Neutral" responses were related to the possibility that the strategic and operational level of the company work together to achieve the conclusion of the KE and that they also have meetings together aimed at finding the root cause of the problems in order to then discuss possible solutions.

4.4 Focus Group

Given the responses to the introductory questions, most represented construction companies in Lima (Peru) were aware of some process improvement systems, such as the Last Planner System and Lean Construction. However, these systems are still new for most of these companies, which means that they are still at a learning stage (theoretical). Accordingly, there are still many problems during the application of these systems in the construction sector, such as changing employee mindset and overcoming resistance to cultural change.

The second question had the specific objective of understanding which tools or techniques are best used to solve a problem and then to improve a particular process. Most of the participants did not anticipate the cause of the problems and did not use tools focused on process stability. Likewise, the knowledge of tools used to improve processes is still empirical and not detailed.

The third question referred to the hypothetical case of the incorporation of a KE to improve a process during the construction of a residential building. Accordingly, most participants agreed that they would follow the sequence shown in the method. Furthermore, one participant said that the preliminary flowchart would not help to improve a process in the short term but would do so in the longer term. Also, most participants agreed that the fourth stage (Post-event) was extremely important.

The fourth question intended to determine the method's feasibility and how its planning could be executed within a certain time lapse. The incorporation of the method in the hypothetical case was delimited to between one to two weeks (15 days maximum). Hence, some participants mentioned that the process of improving the problem depends on whether the activity affects the critical path schedule and if it is of great magnitude. No participant presented any idea to optimize the method flow sequence.

Finally, the fifth question sought to address the functionality and applicability of the KE in a real life scenario. The participants agreed that the sequence, structure and purpose of the method was clear. In addition, the terminology used to explain the method step-by-step was simple enough

to facilitate the understanding of the process and of each stage. Moreover, the method's applicability was said to depend on the type of organization and its employees. Some participants mentioned that the method is a powerful tool that helps to organize and structure problem-solving ideas.

5. Conclusions

Currently, there are many philosophies applied to production systems which seek to increase efficiency and performance. In this way, the KE is one of the most popular and implemented mechanisms in the manufacturing industry. The proposed method represents a contribution to the development of a systematic improvement process in the construction sector. The theoretical foundations of the method were based on the STM and SLR which relate to the implementation of improvements in such a way that emphasizes teamwork, encourages the discussion of problems and solutions (relating scientific and creative approaches) and finally, prioritizes continuous but durable improvements over time instead of more radical improvements. Also, this method has a flow-oriented, systematic and practical structure that helps identify problems and their root cause while also aiding in finding solutions and improvements and learning from the best practices of the event.

Through analyzing the results of the final questionnaire and the focus group, it was possible to deduce four important aspects that optimize the proposed method, improving its functionality and applicability in a real life situation. First, the construction sector is constantly changing like some other industries. However, some building companies use tools in isolation, thus obtaining partial and unproductive results. Likewise, the difficulty in changing employee mindsets and overcoming resistance to cultural change hinders the understanding of improvement systems. Also, learning the tools and concepts contained within a KE should be a detailed process and should explicitly promote and motivate organizational and cultural change while mitigating resistance to change.

Second, although current knowledge about Lean Thinking is still empirical, many participants defined this philosophy in different ways but with the same objective of reducing waste in productive processes. In relation to the tools listed to solve problems, Lean Construction and TPS tools were cited, which indicates that the participants know of these tools and their concepts, which facilitated the comprehension and incorporation of the method.

Third, the time lapse for applying the method will depend on the process that is being improved. For instance, there are different repetitive activities that take place during construction, but some of these are more complex and extensive than others. Consequently, the time lapse in which a KE can be executed is relative. Nevertheless, this event must be executed over a short period of time in order to achieve the quick benefits offered by this system.

Finally, the sequence, number and terms used to describe each stage were adequate in facilitating the method applicability and functionality in a real life scenario. In addition, construction companies generally have performance metrics used to execute a certain process. Therefore, the participants can contrast and analyze these initial metrics with the results obtained after the KE. Then, the new metrics can serve as a reference for starting a new KE.

A limiting factor in this study was the fact that all participants were from Peru and that the evaluation was completed there. However, this evaluation could be carried out in other regions and countries and could be conducted with another sample having a similar or superior profile, which would allow the incorporation of new improvements to the method. In addition, the method must also be implemented using case studies in order to assess its contribution to the performance of the improvement process in the construction sector.

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