AMERICAN UNIVERSITY OF BEIRUT

DEVELOPING A TOOL TO ASSESS AND ENHANCE THE WORKERS' UNDERSTANDING OF LEAN CONCEPTS IN CONSTRUCTION

by
RANIA ALBANNA

A thesis
submitted in partial fulfillment of the requirements
for the degree of Master of Engineering
to the Department of Civil and Environmental Engineering
of the Faculty of Engineering and Architecture
at the American University of Beirut

Beirut, Lebanon
January 2019

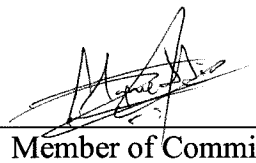
Developing a Tool to Assess and Enhance the Workers' Understanding of Lean Concepts in Construction

By
RANIA MAHMOUD ALBANNA

Approved by:

Dr. Farook Hamzeh, Assistant Professor — Advisor
Civil and Environmental Engineering

Dr. Issam Srour, Associate Professor — Member of Committee
Civil and Environmental Engineering



Dr. Ibrahim Alameddine, Assistant Professor — Member of Committee
Civil and Environmental Engineering

Date of thesis/dissertation defense: [January28th, 2019]

AMERICAN UNIVERSITY OF BEIRUT

THESIS, DISSERTATION, PROJECT RELEASE FORM

Student Name:

Albanna	Rania	Mahmoud
Last	First	Middle

● Master's Thesis ○ Master's Project ○ Doctoral Dissertation

■ I authorize the American University of Beirut to: (a) reproduce hard or electronic copies of my thesis, dissertation, or project; (b) include such copies in the archives and digital repositories of the University; and (c) make freely available such copies to third parties for research or educational purposes.

☐ I authorize the American University of Beirut, to: (a) reproduce hard or electronic copies of it; (b) include such copies in the archives and digital repositories of the University; and (c) make freely available such copies to third parties for research or educational purposes after:

One ---- year from the date of submission of my thesis, dissertation, or project.

Two ---- years from the date of submission of my thesis, dissertation, or project.

Three ---- years from the date of submission of my thesis, dissertation, or project.

Rania 8/2/2019

Signature Date

ACKNOWLEDGMENTS

I would like to thank Dr. Farook Hamzeh for his advice, guidance, and supervision throughout my thesis work. His patience, assistance, and help have empowered me to accomplish my thesis.

I would like as well to thank my committee members Dr. Issam Srour and Dr. Ibrahim Alameddine for their helpful feedback.

Many thanks to my friends and family who were supportive and encouraging in my journey to get my master's degree.

I would like to dedicate this thesis work for everyone who believed in me during the times I least believed in myself.

AN ABSTRACT OF THE THESIS OF

Rania Mahmoud Albanna for Master of Engineering
Major: Civil and Environmental Engineering

Title: Developing a Tool to Assess and Enhance the Workers' Understanding of Lean Concepts in Construction

In order to reap the benefits of Lean Construction, construction companies should integrate, empower and enable all the personnel involved in the construction process whether on or off site. However, construction workers need to be trained about lean construction concepts and principles. The purpose of this paper is to develop a tool to assess and enhance the workers understanding of Lean concepts in construction. In this study, the lean construction concepts are categorized into eight main areas: planning and control, standardization, pull production, wastes, kaizen, site organization, quality and safety. A lean construction worker knowledge profile was formulated based on the aforementioned categories. This profile encompasses all the knowledge, information, and lean background that a construction worker should distinguish, utilize and harness on the construction site. This lean profile formed the basis for a survey done on different construction sites in Lebanon. It allowed us to understand the weaknesses of construction workers. Out of the eight categories, construction workers lacked the required acquaintance in pull production and wastes. As a result, training exercises and games are recommended to instill lean construction concepts in the everyday behavior, practice and job performance of construction workers.

CONTENTS

ACKNOWLEDGMENTS viii

ABSTRACT ix

LIST OF ILLUSTRATIONS 13

LIST OF TABLES 14

Chapter

I.PROBLEM STATEMENT 14

II.LITERATURE REVIEW 2

A.Role of People in Lean Culture……2

B.Training Characteristics: Requirements and Challenges…….5

III.RESEARCH OBJECTIVES 11

A.Developing a lean construction worker knowledge profile……...11

B.Assessing the worker's knowledge and weaknesses regarding lean construction concepts……..11

C.Bridging the gap between workers' understanding and lean concepts……..11

IV.RESEARCH QUESTIONS 12

A.Research question 1……...12

B.Research question 2……....12

C.Research question 3……12

V.RESEARCH METHODOLOGY AND METHODS 13

A.Task 1: Develop a lean construction worker knowledge profile:……..14

1.Standardization (Tezel 2011)……...16
2.Pull Production (Arbulu et al 2003)…….17
3.Waste (Ohno 1988)…….....18
4.Kaizen (Liker 2004)…….18
5.Site Organization…….19
6.Quality (Liker 2004)……....19
7.Safety (Bernstein and Jones (2013))……19
8.Planning and Control: (Brady 2014)……20

B.Task 2: Prepare the Questionnaire and Pilot Test It…….....20

C.Task 3: Conduct the Questionnaire……21

D.Task 4: Analyze and Assess the Questionnaire and Identify the Areas of Weaknesses……22

E.Task 5: Specify What Games Can Be Used to Fill the Gap between the workers knowledge and Lean Knowledge Profile……...22

F.Task 6: Draw Conclusions and Recommendations……23

G.Task 7: Develop the assessment tool…….....23

VI.THE SURVEY 24

A.Developing the survey……...24

B.Data Collection……..… 26

VII.DATA ANALYSIS AND DISCUSSIONS 30

A.Analyzing the data received from the survey:……...30

B.Analyzing the Eight Categories of Lean Knowledge Profile in Construction for Construction Workers:……...43

VIII.RECOMMENDATIONS AND OBSERVATIONS 48

A.Recommendations to address the areas of weaknesses in lean construction understanding……48

B.Observations……..51

IX.CONCLUSIONS 53

X.RESEARCH LIMITATIONS.....55

Appendix

I.SURVEY DATA 57

II.R CODE 57

III.ENGLISH SURVEY 59

IV.ARABIC SURVEY 63

REFERENCES……67

ILLUSTRATIONS

Figure Page

1: Process Flowchart 13

2: Extraction of the Construction Workers Lean Profile 15

3: Categories of the Construction Worker Lean Profile 16

4: A group of construction workers gathered to fill the survey 27

5: Box Plot for Wastes 39

6: Box Plot for Standardization 40

7: Box Plot for Site Organization 40

8: Box Plot for Safety 41

9: Box Plot for Quality 41

10: Box Plot for Pull Production 42

11: Box Plot for Planning and Control 42

12: Box Plot for Kaizen 43

13: Boxplot for the Eight Categories of Lean Knowledge Profile 47

TABLES

Table Page

1: Distribution of Participants in Structured Interviews 21

2: Summary of Collected Data..... 27

3: Questions and categories 30

4: Sign test for Questions: Q1, Q25, Q32, Q37, Q7, Q18, Q27, Q28, and Q13..... 35

5: Sign Test for Questions: Q8, Q2, Q9, Q10, Q19, Q34, Q40, Q11, Q20, Q6, Q15, Q24, Q30, Q31, Q36, Q39, and Q42 36

7: Sign Tests for Questions Q17, Q26, Q38, Q3, Q12, Q16, Q21, Q29, and Q35..... 38

8: The average answers per respondent for each category 43

9: P-values for the Pairwise Wilcox Test for differences between the 8 lean categories 45

10: The Lean Games and Their Corresponding Category 49

CHAPTER I

PROBLEM STATEMENT

Lean construction has been proving over and over again its benefits to the construction industry (Conte 2001). Lean construction claims new roles and responsibilities for construction workers who are entailed to meticulously understand and pertain lean concepts. However, such a transformation in the status-quo and the work environment is faced by many stumbling blocks including the ill-trained labor force, lack of commitment and reliability among the construction workers and foremen, and lack of lean construction implementation in construction companies. Companies and the academic communities have attempted to teach, train and educate students, managers and engineers on lean construction with limited focus on the work force. Studies which had focused on workers offered solutions such as monetary schemes (Gracia et al 2006); yet these schemes have failed to really integrate or empower construction workers to attain their new roles in lean construction. Unfortunately, construction workers are looked at as a passive resource, and it isn't until they are engaged and enabled by the new processes that the benefits of lean will be completely grasped (Silvon et al. 2010). Since the outcomes of lean construction and trained construction workforce are beneficial, an assessment tool is proposed to assess the knowledge of the construction workers regarding lean construction concepts, to identify weaknesses in their understanding of lean construction principles and to propose simulation exercises/games that augment their lean awareness and routine.

CHAPTER II

LITERATURE REVIEW

A. Role of People in Lean Culture

Whilst lean emphasizes on reducing wastes, it is also about changing the corporate culture. Lean doesn't only require a set of tools but also a shift in the way employees behold and execute their work (Liker 2004). Change doesn't happen overnight. Building a lean culture requires years of painstakingly applying management approaches with consistent principles. The core concepts of lean reckon on team work, problem solving and continuous improvement, which is one of the 4P's of the Toyota Production System.

The goal is to make the company and all the employees centered on a common language, fundamental principles and basic lean principles and practices. Familiarizing the workplace with lean methods necessitates the learning of new concepts- an ameliorated understanding of how work should be executed, organized, and how teams operate and what role everyone plays. One of the ways to fulfill the previously mentioned goals is through coaching and the continuous improvement routines. Greenleaf (2002) suggested the servant leadership concept which is based on the idea that the leader should do what's needed to make the ones whom he is serving become effective and creative in performing their work. The lean leader has to craft and maintain the required conditions for the employees, workers and labor force to foster, cherish and boost their skills, capabilities and attitudes towards continuous improvement. Thus, in order to impact the behavior of the workers, Beer et al. (1995) suggest enforcing of new roles and responsibilities, and modifying the relationship

between the team members in favor of disseminating and employing lean construction principles.

Olivella et al. (2008) observed that the traits and characteristics related to the human capital and their roles were common in organizations that adopted lean. These characteristics include: the continuous learning and training of the workers, the focus on team work, the standardization of the work, the multi-skilling and adaptability of the workers, the reward system designed for both individuals and teams, the teams participation in quality control, and work planning functions and the commitment of the workers and teams to the common values shared by the organization. Hamzeh (2011) thinks as well that the organizations whose culture is based upon unremitting experimentation, acknowledging breakdowns and reflecting upon them, transparency and sharing information among team members possess the suitable foundation for a thriving lean construction culture.

On the other hand, the obstacles that confront the implementation of lean in construction projects include: lack of leadership, team chemistry and human capital, resistance to change, poor implementation of planning, and the psychological and organizational culture as barriers to activate lean construction and the last planner system in construction sites (Ballard and Kim 2007; Hamzeh 2009; Viana et al. 2010). Some of these difficulties encompass incompatible personnel qualifications and the difficulty in adapting to the newly introduced Lean culture (Viana et al. 2010). Chan et al. (2004) categorized the key performance indicators for the success of a construction project into two categories: objective and subjective measures. Construction team's satisfaction and the accident rate on the construction project were among those key performance indicators that govern the success of a construction project. In a large project in the urban area of Fortaleza, Brazil, lean

construction was adopted and great success was achieved; however one of the greatest difficulties often observed was to promote (1) lean construction concepts and tools, (2) the philosophy of planning and production, and (3) the importance of engraining these concepts within the field employees such as foremen, crew leaders and construction workers (Barbosa et al, 2013).

Thus, in order to overcome these difficulties, organizations have started teaching engineers and managers who are participating in the engineering processes about the Lean culture, its philosophy, concepts, tools, methods and deployment modules, but haven't focused much on the downstream foremen, construction workers and last planners. The lean implementation is a long process that requires a strong commitment from the owner, top management, and along with every person involved in the construction project. Organizations often fail to take into account the social and philosophical significance when implementing lean construction (Hamzeh, 2011). The implementation framework suggested by Hamzeh (2011) includes a train the trainer program for the superintendents as well as the foremen. This highlights as well the importance of achieving a shift in the mindset, culture, behavior and way of thinking and doing the work. Thus the current research aims to cultivate a tool to assess the workers' insight of lean concepts in construction through first: forming a survey which tackles the different lean construction categories that needs to be comprehended by construction workers, pinpointing the areas of weaknesses construction workers have regarding lean construction concepts, and finally enumerating the training exercises that can be exploited to seal these gaps.

B. Training Characteristics: Requirements and Challenges

Successful training is about cognizing both organizational goals and employee behavior. Thus employees must be provided with information, knowledge, abilities, and the skills attitudes to be used after attending the training. Training improves the cognitive and behavioral skills of the workers, thus enriching employee effectiveness, knowledge, productivity and efficiency as well as maintaining superiority in the market place. Although contractors are aware of these benefits, they abstain from sending their foremen to attend trainings due to factors like cost, location, accessibility and time (Harrington, et al. 2009). On the other hand, aspects like the commitment and follow-up of the upper management, workers' innate abilities, attitudes and motivation, peer guidance and role-model affects the extent to which workers master the skills afforded throughout the training program (Harrington, et al. 2009). For example, the Latino construction workers had low safety expectations, low self-esteem, and unsafe work practices (Brunette 2004).

Some factors regarding the training itself impact the outcomes of the training; for example, there might be certain gaps between the given material and content of the training on one hand and the trainees' conceptual understanding and skill enhancement on the other hand. In an exploratory study performed with construction workers who attended health and safety training sessions, it was shown that the training program had a serious disconnect between the theory being taught and its practicality on the construction site. And in another assessment of safety trainings done for Latino construction workers in the United States of America, it was observed that many weaknesses existed including: inadequate orientation and skills assessment; inappropriate expectations and task assignment; poor direction, training, and warnings; and inadequate oversight, correction, and motivation (Ringen et al.,

1995). Language barrier among the Latino construction workers, who don't know English language, prohibited the effective safety training and communication between them and their supervisors (O'Connor et al. 2005). Thus, the training method and the trainer's approach towards engaging trainees can have a great impact on their understanding of the training content (O'Connor et al. 2005).

Martin et al (2014) distinguished thirteen training methods mentioned in the literature which are: case study, games-based training, internship, job rotation, job shadowing, lectures, mentoring and apprenticeship, programmed instruction, role-modeling, role play, simulation, stimulus-based training, and team-training (Martin et al, 2014). Burke et al. (2006) classified the training methods into three categories depending on the degree of engagement of the construction workers and based upon the provided thirteen methods: (1) passive methods: the workers only receive information such as: lectures, mentoring, apprenticeship, job shadowing, case study, (2) moderately engaging methods: feedback and reflection upon mistakes is encouraged and supported such as: programmed instructions, internship, games-based training, job rotation, role-modeling, team training, (3) highly engaging methods: behavioral change, modeling, simulation, and two way communication regarding knowledge and actions taken, such as: role-play, simulation, stimulus-based-training. As the extent of engagement increases, the outcomes in terms of the attainment of knowledge and the change in the behavior of construction workers increases. The less robust methods can be improved through an interactive feedback, participation, and the dialogue intended by the trainees (Burke et al. 2006, Mowlam et al. 2010). Error training, that is conducted by guiding trainees to make errors and giving them strategical and emotional feedback and support on how to build corrective measures proved to be a good approach (Lorenzet et al. 2005).

It was indicated by Martin et al (2014) that the majority of the training methods were off-the-job, and lacked the required interaction between the trainer and the trainees. In order to overcome this difficulty, Martin et al (2014) presented the profiles for the training methods which makes it easier for the trainers to select between them based on the needs and circumstances of the trainees. Harrington et al. (2009) highlighted the importance of the following criteria to have a successful tailgate training: (1) relevance between the training and the hazards faced by the crew or might face, (2) crew participation and involvement in the training through suggesting questions, ideas, stories, and solutions, (3) crew demonstration of what was learned using tools, equipment, and procedures, and (4) the actions and processes that are directly applied in the construction site. As a result, the training course should be structured around three main categories: awareness, skill building, and action planning (Canales et al., 2009). A training program that focuses on andragogy that is drawing examples, practical suggestions and presenting information related directly to the workplace would enhance its relevancy from the trainees' point of view (Wilkins 2011). Andragogy focuses on the learner as the main subject of the learning process. The success of a teacher/ trainer is defined not by what the trainee knows but by what he does (Cooke et al. 2006). Hamzeh et al. (2016) emphasized the vitality of discussions and training exercises to establish an effective learning procedure. Gherardi and Nicolini (2002) concentrated on the significance of learning in non-instructional settings, practicing safety more than learning it, actively participating in the training, dialogue and conversations, and acquiring knowledge from the peer workers through active observation and imitation; thus foregrounding the importance of the socio-cultural view of learning. Supervisors and foremen are considered to be the most suitable and effective trainers to conduct such trainings due to the major role they

play on the construction site as the last planners. In a toolbox training program for construction foremen in Denmark about safety communication, safety worksite behavior, foremen's planning, construction workers participation and two way communication, positive changes were observed in the foremen's behavioral leadership role in motivating construction workers, positive attitude towards using safety tools and communicating with construction workers, awareness regarding the operational safety, health risks and the measures to be taken. These changes improved the cooperation between construction workers and increased the active engagement of work crew members in dialogue and problem-solving discussions on site. However to maintain this process of change and ensure that all foremen are applying what was learned in the training program, a culture which favors management support and continuous improvement should be adopted, i.e. a lean culture (Jeschke et al. 2017).

Introducing role models to the construction workers in the training programs shows the workers proven examples of success and encourages them to succeed. The Basic Management Functions Workshop created by Izquierdo et al. (2011) suggests that the best way to illustrate Lean to employees is through recognizable realistic situations where they can exercise their own basic functions. A training program about lean practices should provide the chance for workers to participate in teamwork, communicate collaboratively, and report facts and findings effectively (Izquierdo et al., 2011). It is essential that that these programs be practical and site-oriented so that workers can totally benefit from them (Raghavan et al., 2014). Additionally, simulations and games in a workshop or training session are an efficient way to impact trainees and familiarize them with lean concepts in a practical manner (Tsao et al., 2012).

Lean games are a good way of introducing lean construction to workers. Active learning increases the acquirement of information through involving learners, mimicking real life problems, enhancing team work and communication, and making learners observe the consequences of their action (Clarke 2009). There are many lean construction games which address the engineers, managers and foremen, some of them are targeted towards the management construction concepts, others focus on contracting and some target the supply chain management. When it comes to construction workers, simulation exercises, which earmark their job level in lean construction, can be used to deliver the required lean construction knowledge. It should be taken into consideration that construction workers have low educational background, their work type is of transient nature and that they receive little to no formal task or craft training (Maloney 1977). Simulation exercises make trainees experiment certain situations, take decisions and observe the consequences of these decisions; thus preparing them for what happens in real life (Zoroja 2010). Exercises create a collaborative environment through the involvement of trainees as groups who learn as teams, which enhances the collaborative team spirit among them (Froyd 2008). Thus, simulation games/exercises help construction workers understand and practice lean construction concepts.

The typical model for conducting the training includes the following: a training needs analysis conducted through literature review and onsite survey, data collection and analysis- why training is needed, the areas covered by the training based on the survey that suits the workers, and the measurement and the evaluation of the outcomes and the training effectiveness (Goldstein 1993, Canales et al., 2009). The training course should be structured around three main categories: awareness, skill building, and action planning (Canales et al.,

2009). The use of peer training has been reported to be more efficient and successful than the use of professional trainers as it encourages the workers' engagement and participation (Brunette, 2005).

CHAPTER III

RESEARCH OBJECTIVES

Objective 1: Develop an assessment tool to evaluate and enhance the workers' understanding of lean concepts

This objective will be established through:

A. Developing a lean construction worker knowledge profile

Based on the eight areas of lean construction concepts, which are kaizen, planning and control, site organization, standardization, pull production, safety, quality and wastes, a profile of knowledge aspects that construction worker has to comprehend and employ was accomplished.

B. Assessing the worker's knowledge and weaknesses regarding lean construction concepts

A survey, which is based on the eight categories, was organized to assess the knowledge of workers. This survey sheds light on their weaknesses in lean concepts.

C. Bridging the gap between workers' understanding and lean concepts

Based upon the survey results and in order to bridge the gap between the knowledge profile and the weaknesses found, simulation exercises/games were introduced to teach workers lean construction concepts.

CHAPTER IV

RESEARCH QUESTIONS

A. Research question 1

How to assess the workers' lean construction knowledge?

B. Research question 2

What are the current weaknesses of the Lebanese construction workers in lean construction?

C. Research question 3

What are lean games/simulation exercises that can be used to bridge the gap between workers and lean concepts?

CHAPTER V

RESEARCH METHODOLOGY AND METHODS

To achieve the aforementioned research objective, a stepwise research methodology was designed. As a start, a thorough literature review was carried out to come up with the lean knowledge profile of construction workers. Then, a survey that targeted the various lean concepts was administered. The data were then gathered, analyzed, and explored. Based on the results and the examination of the data, conclusion, recommendations, and suggestions are given for employment.

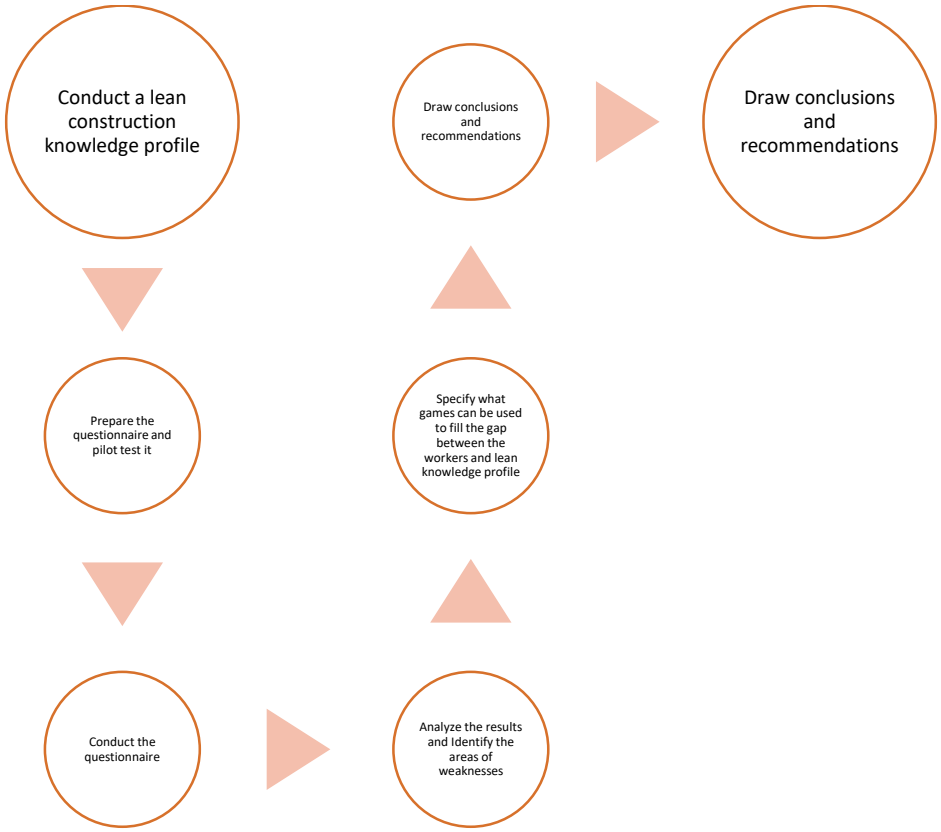


Fig. *1:* Process Flowchar

To achieve the previously mentioned research objective, the following tasks were accomplished:

A. Task 1: Develop a lean construction worker knowledge profile:

A meticulous review on previous studies that adopt the topics of lean construction was executed. Its concepts were pinpointed and categorized in eight major domains: 1) kaizen, 2) planning and control, 3) pull production, 4) waste, 5) quality, 6) site organization, 7) standardization, and 8) Safety. These concepts were derived in reference to the 14th principles of Toyota, lean construction references and papers, the classical references of lean construction (koskela 1992, 2000) and the lean construction categories of practices in IGLC proceedings organized by Etges et al. 2012. However, the peculiarity of construction workers as well their job level requirements and what they should be acquainted with at the lean construction level was taken into account. Thus, and in order to come up with a lean construction worker knowledge profile, the categories were adjusted to tackle only the construction workers required level of knowledge in lean.

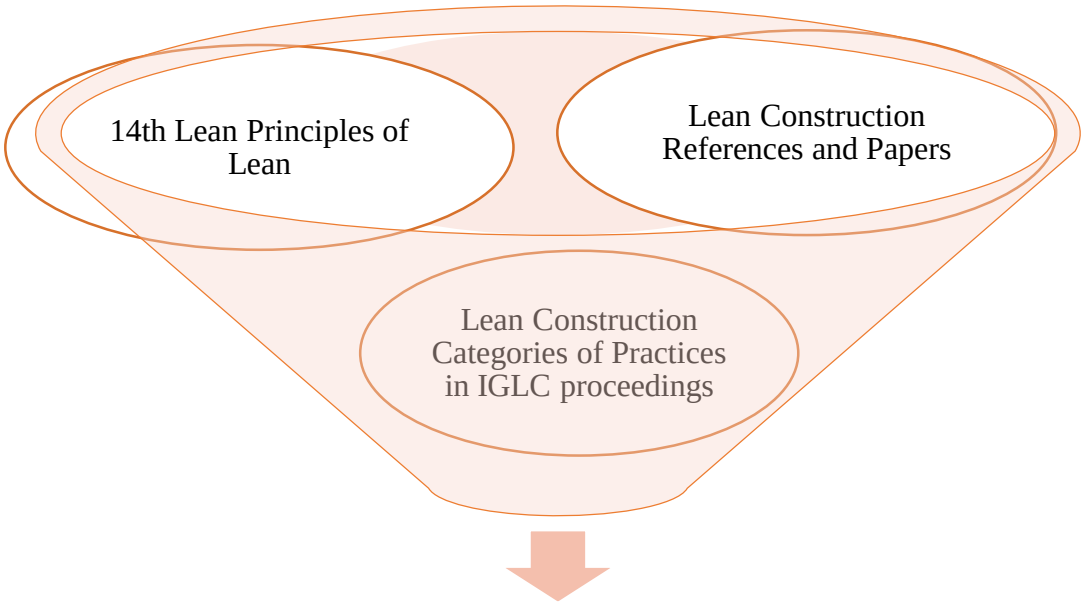


Fig. 2: Extraction of the Construction Workers Lean Profile

Based upon the previously mentioned lean domains, specified and detailed lean construction worker knowledge profile is formulated. It encompasses all the knowledge, information, and lean background that a construction worker should distinguish, utilize and harness on the construction site.

This is the construction worker lean knowledge profile:

Fig.3: Categories of the Construction Worker Lean Profile

1. **Standardization (Tezel 2011)**

- Keep only the needed tools, materials and resources in the work area (red tag area, trash)
- Put everything in its place and make a place for everything (use tape, outline areas, use peg boards)

- Mark the crane spots unloading bays, areas of work and the floor to highlight the walkways and location of tools and materials such that a safe and efficient working environment is established
- Color code the places by trade, traffic and material logistics plans
- Clean the tools and working areas when done or before
- Implement a task by following a standardized procedure
- Ensure, as a construction worker that you are following the standards through periodic self-evaluation
- Make shadow boards and use them to organize and ensure the availability of the tools

2. Pull Production (Arbulu et al 2003)

- Understand the sequence of tasks
- Realize the internal (successor) and the external customers (client/predecessor) of a process
- Provide the right products in the right place at the right time
- Make the processes transparent (Koskela 2000)
- Understand the types of flow, materials , flow of information, crew, space,,,
- Understand and practice production-ordering- Kanban and transport/ supplier Kanban
- Know how to use the Kanban cards , production leveling Heijunka board, in station quality (jidoka) through Andon (Tezel 2011)

3. Waste (Ohno 1988)

- Understand and learn how to eliminate the types of wastes)
- Avoid rework through using simple job aids such as checklists and standardized work plans
- Reduce unnecessary movement of workers on the construction site
- Unnecessary transportation of materials, equipment, tools
- Limit unnecessary processing of the work
- Making do (starting a task without its standard inputs or the execution of a task is continued where one of its inputs has ceased) (Koskela 2004)
- Task diminishment (executing a task in a way that doesn't comply with the specifications) (Patton 2013)
- Defects produced from executing a task in the wrong way
- Simplifying by minimizing the number of steps to perform a certain task

4. Kaizen (Liker 2004)

- Reflect upon the root causes of a problem and take preventive measures to avoid its occurrence in the future
- Practice kaizen everyday through every work procedure done
- Make reliable promises (Hamzeh 2011)
- Suggest new ideas about how to do my work, to improve safety, product quality , productivity or quality of work life
- Don't hide problems
- Ensure working as a team (Hamzeh 2011)

- Ensure viewing the process and the result, not the result alone

5. Site Organization

- Ensure that flow paths of people are properly marked, unobstructed, paved, flagged, protected and empty
- Ensure a clean and organized site with signs : place for inventory, jobs, technical room, warehouse, cafeteria, floor numbers, self-explaining signs
- Dedicate clear areas with signs for materials
- Gather small parts orderly in bins and at locations close to utilization
- Use signs for the materials in the stock with their corresponding quantities for replenishment

6. Quality (Liker 2004)

- Ensure quality right the first time even if it means to slow down or stop to enhance productivity on the long term
- Do in process-self inspection
- Ask 5 whys to understand the root causes of a problem
- Understand the regular quality control procedures for concrete, pouring ….

7. Safety (Bernstein and Jones (2013))

- Understand and practice safety signs and instructions instructions and procedures in areas related to scaffolding, fall protection, excavations, ladders,

head protection, excavations, electrical,… (OSHA, operational safety and health administration, U.S Department of Labor, www.osha.gov)

- Adequately use safety protection tools (helmet, glasses, protection shoes)

8. Planning and Control: (Brady 2014)

- Organize the daily work and put a plan to execute it
- Know the weekly work schedule
- Get involved in the planning of the work and the daily huddle meetings by giving my input, progress and problems while doing a certain task
- Know the specified work as to content, sequence, timing and outcome
- Define/ know the component of the product to be constructed as to content, timing, sequence, outcome, and describe the work to be done as shown in plans and specifications

B.Task 2: Prepare the Questionnaire and Pilot Test It

For each of the previously mentioned categories and points, simplified statements were designated to be rated on a Likert scale from 1 to 7. The participants were asked to answer each question according to the following 1 to 7 scale (1-entirely disagree, 2- mostly disagree, 3-somewhat disagree, 4- neither agree nor disagree, 5-somehow agree, 6- mostly agree, 7-strongly agree), showing how much their answers reflect their opinions, beliefs and behaviors regarding the statements present in the questionnaire.

A questionnaire was prepared that handles all the above-mentioned lean construction knowledge requirements. This questionnaire was pilot tested on lean knowledgeable and non-lean knowledgeable individuals and adjustments were made. It was given to different construction companies in Lebanon in the areas of Metn, Beirut and Aley. For this study, the author arranged structured face-to-face interviews. After directing numerous interviews, the data was gathered and examined using statistical means. The distribution of the respondents varied between workers and skilled workers. Table 1 shows the distribution of the respondents in the structured interviews:

Table 1: Distribution of Participants in Structured Interviews

	Percentages	Average Years of Experience
Skilled Workers	53%	8 years
Non-skilled Workers	47 %	3 years

Since the targeted construction workers were illiterate and they don't know how to use the laptop, in addition to the fact that they don't know English. As a result, the only possible way to contact and conduct this questionnaire was through face to face interviews.

C. Task 3: Conduct the Questionnaire

The interview was conducted at different construction projects in Lebanon and addressed 7 construction companies. It took about fifteen to twenty minutes to be completed. The interviewer read the questionnaire out loud and the respondents answered. The

interviewer ensured that the respondents were able to read, write and understand the information in hand. The interviewer ensured that all the questions were understood to avoid false results and that they were answered. The respondents were undoubtedly assured that their answers were confidential.

D. Task 4: Analyze and Assess the Questionnaire and Identify the Areas of Weaknesses

The data was collected and statistical analysis was conducted. The knowledge of the construction workers was assessed through the aforementioned questionnaire which targeted the workers' lean construction knowledge. This survey showed the areas of weaknesses in lean for the construction workers. Statistical data analysis and statistical outcomes were assessed and considered to understand the weaknesses of the construction workers and thus draw the corresponding graphs. These results will help in assessing and understanding the current situation of the construction workers in a sample of construction sites in Lebanon.

E. Task 5: Specify What Games Can Be Used to Fill the Gap between the workers knowledge and Lean Knowledge Profile

A thorough literature review regarding the games used to teach lean construction was done. Lean games targeted mainly the students, engineers and managers; however few games can be used to teach lean construction to construction workers. These games should take into consideration the level of knowledge which should be required by construction workers in lean. These games must take into account that construction workers: 1) have limited to no

educational background, 2) learn by doing and practicing their job on site, 3) most of them work on daily informal contract basis (Srour et al. 2017).

F. Task 6: Draw Conclusions and Recommendations

After scrutinizing the results, areas of weaknesses in the lean knowledge of the construction workers was highlighted, and an assessment tool was designed to recognize and enhance the knowledge of construction workers on lean concepts.

G. Task 7: Develop the assessment tool

Based upon the results and the findings of the questionnaire, in addition to the characteristics of the trainings and programs, an assessment tool was designed to rate the understanding of the lean concepts by construction workers, find the areas of weaknesses, and suggest simulation games to let workers understand lean concepts.

CHAPTER VI

THE SURVEY

A. Developing the survey

In order to rate the current knowledge of the construction workers concerning lean construction concepts, a survey was prepared to collect the needed data for this analysis. The survey began with a question regarding whether the respondent was a worker or a skilled worker and his/her years of experience.

The respondents were not required to write their names or any personal information. It was mainly targeted towards assessing their knowledge and their current practices in the construction site regarding the eight areas which are: 1) Kaizen, 2) Waste, 3) Pull production, 4) Quality, 5) Safety, 6) Planning and Control, 7) Site Organization and 8) Standardization. These categories were simplified in a way that targets what each construction worker has to comprehend and use.

The respondents were exclusively Syrian. The survey contains 42 questions where the respondent answered on a Likert scale from 1 to 7. The respondents answered the statements based on how much do they agree on these statements and how much they employ them in their usual daily work. The survey was pilot tested on two persons; one who is lean knowledgeable and the other was not. The survey was prepared in English then translated to Arabic s. Several iterations were carried out in order to come up with the most suitable indirect, implicit, and deducible statements. They were inferred from the previously mentioned and simplified lean knowledge profile in addition to the training games and exercises found in the literature review. A copy of the survey in both English and Arabic

versions is attached in the appendix for further information. The questionnaire started with an assurance regarding its confidentiality. The questions aimed to gather specific information about the way construction workers execute, and practice daily work, in addition to their indirect vision regarding lean construction concepts. As a result, the survey tried to assess in an indirect mode the way construction workers executed their work in accordance to lean construction concepts, starting from kaizen, pull production, planning and control, waste, quality, safety, site organization, and standardization.

To sum up, the survey was developed to gather data in order to analyze, understand, rank and recognize the knowledge of lean construction on different levels: extremely weak, poor, fair and good. To analyze the kaizen category several statement were raised in order to figure out whether the construction workers value team work, make reliable promises, make their tasks transparent, and cogitate upon their work mistakes. To study to what level construction workers practice and know standardization, numerous statements addressed the topic: standardization of the tasks, standardized locations and shadow boards, the practice of the 5s methodology. To know to what degree construction workers know/practice pull production, production ordering Kanban and supplier Kanban, process transparency, sequence and task responsibility. Understanding construction workers performance in safety pinpointed on practicing safety, wearing and sticking to safety procedures. Regarding the quality category, the target was to realize whether construction workers do in process self-inspection and view quality as a priority. For the site organization aspect, construction workers were asked to rate the importance of a clear, organized site with signs and with properly marked flow paths. Construction workers were asked about the types of wastes and how do they view these wastes.

B. Data Collection

To collect the data, a structured face to face interview was done in different construction sites in Lebanon. Different construction companies were visited in different areas in Lebanon in the areas of Metn, Beirut and Aley. The construction site engineers were called and the authorization to come to the construction site was given. Before visiting the site, the responsible project manager or site engineer was contacted. In some cases, a previous meeting was done where the project manager and the general foremen were introduced to the survey, read the questions and approved the performance of the face to face interviews. It is worth mentioning that several companies refused to take part of this survey.

When on site, the first thing was to introduce myself, and then the target behind this study. All the questions were explained in order to avoid false results. On most construction sites, the construction workers were grouped in a room or in a small circle in order to fill the survey, where up to 8 workers were grouped together. Figure 4 shows a group of construction workers filling the survey while I am explaining the questions.

Fig.4: A group of construction workers gathered to fill the survey

The total number of filled surveys was 73. Table 2 below shows the mean, median, mode, standard deviations, variance, and the maximum and minimum for each question. All the collected data are attached in the appendix for more information.

Table 2: Summary of Collected Data

	Mean	**Median**	**Mode**	**St. Deviation**	**Variance**	**Range**	**Minimum**	**Maximum**
Q1	5.7	7.0	7.0	2.2	5.0	6.0	1.0	7.0
Q2	4.4	5.0	7.0	2.6	6.9	6.0	1.0	7.0

Q3	5.5	7.0	7.0	2.1	4.3	6.0	1.0	7.0
Q4	4.6	5.0	7.0	2.6	6.6	6.0	1.0	7.0
Q5	4.3	5.0	7.0	2.5	6.3	6.0	1.0	7.0
Q6	3.4	3.0	1.0	2.4	6.0	6.0	1.0	7.0
Q7	5.6	7.0	7.0	1.9	3.7	6.0	1.0	7.0
Q8	4.0	4.0	7.0	2.5	6.3	6.0	1.0	7.0
Q9	3.5	4.0	1.0	2.3	5.3	6.0	1.0	7.0
Q10	3.6	4.0	1.0	2.7	7.1	6.0	1.0	7.0
Q11	3.7	5.0	7.0	2.6	6.7	6.0	1.0	7.0
Q12	4.3	6.0	7.0	2.5	6.2	6.0	1.0	7.0
Q13	4.9	7.0	7.0	2.0	3.9	6.0	1.0	7.0
Q14	4.0	5.0	7.0	2.3	5.5	6.0	1.0	7.0
Q15	3.8	5.0	7.0	2.5	6.2	6.0	1.0	7.0
Q16	4.3	6.0	7.0	2.5	6.2	6.0	1.0	7.0
Q17	4.9	7.0	7.0	2.2	4.7	6.0	1.0	7.0
Q18	5.2	7.0	7.0	1.9	3.8	6.0	1.0	7.0
Q19	2.7	2.0	1.0	2.1	4.6	6.0	1.0	7.0
Q20	3.7	4.0	1.0	2.5	6.4	6.0	1.0	7.0
Q21	4.5	6.5	7.0	2.5	6.2	6.0	1.0	7.0
Q22	4.3	6.0	7.0	2.5	6.1	6.0	1.0	7.0
Q23	4.1	6.0	7.0	2.3	5.4	6.0	1.0	7.0
Q24	1.6	1.0	1.0	1.4	1.9	6.0	1.0	7.0
Q25	5.2	7.0	7.0	1.7	3.0	6.0	1.0	7.0
Q26	4.8	7.0	7.0	2.3	5.2	6.0	1.0	7.0
Q27	5.4	7.0	7.0	1.9	3.7	6.0	1.0	7.0
Q28	5.7	7.0	7.0	1.9	3.5	6.0	1.0	7.0
Q29	4.8	6.0	7.0	2.2	4.9	6.0	1.0	7.0
Q30	2.8	3.0	1.0	2.3	5.1	6.0	1.0	7.0
Q31	3.1	2.5	1.0	2.3	5.3	6.0	1.0	7.0
Q32	5.8	7.0	7.0	1.9	3.7	6.0	1.0	7.0
Q33	4.3	5.0	7.0	2.4	5.8	6.0	1.0	7.0
Q34	3.6	4.0	7.0	2.2	4.7	6.0	1.0	7.0
Q35	4.8	6.0	7.0	2.1	4.6	6.0	1.0	7.0
Q36	4.2	5.0	7.0	2.4	5.9	6.0	1.0	7.0
Q37	5.5	7.0	7.0	2.0	3.9	6.0	1.0	7.0
Q38	5.4	7.0	7.0	1.8	3.2	6.0	1.0	7.0
Q39	2.7	2.0	1.0	2.1	4.4	6.0	1.0	7.0
Q40	3.3	3.0	1.0	2.2	4.7	6.0	1.0	7.0
Q41	4.4	5.0	7.0	2.4	5.9	6.0	1.0	7.0

Q42	3.8	4.0	1.0	2.3	5.3	6.0	1.0	7.0

CHAPTER VII

DATA ANALYSIS AND DISCUSSIONS

A. Analyzing the data received from the survey:

The questions addressed in the survey fall into one of these categories: 1) Kaizen, 2) Waste, 3) Pull production, 4) Quality, 5) Safety, 6) Planning and Control, 7) Site Organization and 8) Standardization. The total number of questions was 42. Seven questions targeted Kaizen (Q1, Q7, Q8, Q17, Q25, Q32, and Q37). Seven questions targeted Waste (Q15, Q24, Q30, Q31, Q36, Q39, and Q42). Six questions targeted pull production (Q3, Q10, Q19, Q27, Q34, and Q40). Five questions targeted quality (Q4, Q11, Q20, Q28, and Q35). Three questions targeted safety (Q12, Q16, and Q21). Six questions targeted planning and control (Q2, Q9, Q18, Q26, Q33, and Q38). Five questions targeted site organization (Q5, Q13, Q14, Q22, and Q41). Three questions targeted standardization (Q6, Q23 and Q29)

All the questions with their corresponding categories are mentioned in table 3 below.

Some questions were asked in the opposite way to avoid bias which are: Q2, Q4, Q5, Q6, Q8, Q9, Q10, Q11, Q12, Q15, Q16, Q19, Q20, Q21, Q22, Q24, Q30, Q31, Q34, Q39, Q40, Q41, and Q42. Thus, the answers to these questions were reversed in order to have 1 as the lowest and 7 as the highest score.

Table 3: Questions and categories

Q1.	I review my work mistakes with the foremen, and I suggest preventive measures to avoid its occurrence in the future.	Kaizen
Q2.	When faced with a problem, I leave it as it is.	Planning and Control
Q3.	I know the time I take to complete a certain task.	Pull Production

Q4.	If I'm in a hurry, I prefer to sacrifice quality over time.	Quality
Q5.	If I am in a hurry, it is okay if I do not wear a safety helmet.	Site Organization
Q6.	In our company, each foremen execute the same task using their own different methods.	Standardization
Q7.	If I found a better way to perform a task, I show the fellow worker how to do it.	Kaizen
Q8.	There is no point in knowing the causes of a problem at the construction site because we will often face problems.	Kaizen
Q9.	We are too busy working we don't even have time to review why a planned activity was not accomplished.	Planning and Control
Q10.	If I give a promise that I will finish my work on a certain date, its ok if I delayed it one, two or three days.	Pull Production
Q11.	When I encounter a previously made task related to my work and done in a wrong way, I continue working on my job in a normal way.	Quality
Q12.	I am very focused on my work in a way that I forget about the safety signs.	Safety
Q13.	It is better if everything is marked on the construction site, for example, location of tools, material unloading, floor path markings, waste bins, …	Site Organization
Q14.	In a certain working area, I only keep the materials and tools that I use for performing my task in that area and nothing else.	Site Organization
Q15.	I think that unloading large quantities of materials not immediately required at the construction site is quite good.	Waste
Q16.	If I'm in a hurry, it's okay if I don't wear the safety helmet.	Safety
Q17.	I always try to find the root cause of a mistake I made.	Kaizen
Q18.	I think there should be a set of work rules that everyone should abide by and those rules should be clear for everyone.	Planning and Control

Q19.	It's ok if sometimes we are busy with lots of work to do and at other times we have lack of work.	Pull Production
Q20.	When I do a task, it’s ok if it is not up to the quality standards. It's the job of the QC.	Quality
Q21.	There is a mess on the construction site, so I think there is no purpose for having clear and protected paths on site.	Safety
Q22.	I think materials can be stored throughout the site, in the building, on the roof, in different rooms, on the site and in the corridors.	Site Organization
Q23.	There is a standardized procedure to do a task.	Standardization
Q24.	If I do not have any work to do, I can still find a preparatory job to do.	Waste
Q25.	I introduce new suggestions and ideas on how to do my task.	Kaizen
Q26.	I organize what I do every day and I have my plan of doing my work.	Planning and Control
Q27.	I think reliable promising is an important value which should be respected and everyone on the construction site should stick to it.	Pull Production
Q28.	I try my best to do the task right the first time even if it takes more time to do it.	Quality
Q29.	I think that if I follow the same procedures to do a task I will get same results every time.	Standardization
Q30.	When I work at the construction site, I leave the construction waste until the task is completed then I collect them instead of cleaning as I go.	Waste
Q31.	I can start a task even if all its prerequisites are not ready.	Waste
Q32.	I think there is always a room for improvement in the way I do a task.	Kaizen
Q33.	The foremen gives me my weekly work schedule at the beginning of the week.	Planning and Control

Q34.	It’s okay if different crews who work on different jobs are present in the same working area while using different materials.	Pull Production
Q35.	I do in process inspection for the task I regarding quality.	Quality
Q36.	I think I can minimize the number of steps to do a process.	Waste
Q37.	Everyone in the company emphasizes the importance of applying the company's values and goals.	Kaizen
Q38.	The foremen provides us with all the information required to do our job such as what we should do, when, where and with whom.	Planning and Control
Q39.	It's ok if we waited for the materials either to arrive to the construction site or to change its position.	Waste
Q40.	I think it is pretty fine to disrupt my work on a certain task to do another task and get back to it after a certain time.	Pull Production
Q41.	Organizing construction materials and tools in bins, standard pallets and bags is a waste of time.	Site Organization
Q42.	I usually spend some time every day searching for materials, equipment or information.	Waste

In order to assess the results, non-parametric tests were used. A one sample sign test was done to check the median of the questions and categorize it. After entering the data for each respondent on an excel sheet, the data was imported to R Studio, where the analysis began. Each respondent answered the 42 questions in the survey. All the answers for the same question were gathered. Each question in the survey was related to one category of the lean previously discussed. In order to assess and understand the current knowledge of the construction workers regarding each category, a box plot was generated for each of the 42 questions. In order to better assess each of the questions, the analysis was made regarding the following criteria:

- Extremely weak level <4: this level shows that construction workers have extremely weak knowledge in lean construction concepts
- Poor level =5: this level shows that construction workers possess poor knowledge in such categories
- Fair level=6: this level shows that construction workers possess fair knowledge level regarding lean construction
- Good level=7: this level shows that construction workers possess a good level of knowledge in lean construction

Table 4 shows the questions' number, the null hypothesis test, sign test p-value and the corresponding category. The exploration of the questions mentioned in table 4 involved the use of a one sample sign test which was used to check if the median response was less than or equal to 6.

The analysis of questions, Q1, Q25, Q32, Q37, and Q7 which represent Kaizen, showed that most of the respondents agreed or strongly agreed that they review their work mistakes with the foremen, introduce new suggestions on how they do their work, emphasize the values of their company, and help their fellow colleagues. This seemingly perfect attitude is due to the fact that the people in general and workers in particular like to introduce themselves in a favorable way, so they will be reluctant to admit to unsavory attitudes. This type of bias is a response bias. Thus the respondents' answers in kaizen, which refers to continuous improvement, are biased toward what they believe is socially and ethically desirable: continuously improve and develop themselves. For the analysis of question Q13 most of the respondents agreed or strongly agreed that it is better if everything was marked on the construction site.

Table 4: Sign test for Questions: Q1, Q25, Q32, Q37, Q7, Q18, Q27, Q28, and Q13

Question	Null Hypothesis (H0)	Sign test p-value	Decision	Discussion	Category
Q1	The population median of question 1 is less than or equal to six	4.38E-05	Reject H0	Good	Kaizen
Q25	The population median of question 25 is less than or equal to six	0.02903	Reject H0	Good	Kaizen
Q32	The population median of question 32 is less than or equal to six	0.0003087	Reject H0	Good	Kaizen
Q37	The population median of question 37 is less than or equal to six	0.009329	Reject H0	Good	Kaizen
Q7	The population median of question 7 is less than or equal to six	0.009169	Reject H0	Good	Kaizen
Q18	The population median of question 18 is less than or equal to six	0.0006495	Reject H0	Good	Planning & Control
Q27	The population median of question 27 is less than or equal to six	4.42E-05	Reject H0	Good	Pull Production
Q28	The population median of question 28 is less than or equal to six	9.72E-05	Reject H0	Good	Quality
Q13	The population median of question 13 is less than or equal to six	0.04347	Reject H0	Good	Site organization

The analysis of questions in table 5 representing Waste, showed that construction workers have not only a serious lack of knowledge about the types of waste, but also they don't practice any enhancing procedures to reduce waste generation. As a result, most of the respondents don't have any knowledge regarding the waste and types of wastes in lean construction which are mainly: unnecessary movement of workers, materials, equipment and tools, making do, task diminishment and workers waiting for work.

The analysis of the questions Q10, Q19, Q34 and Q40, in table 5, which represent pull production, showed that the surveyed construction workers had weak knowledge regarding pull production. This shows that the traditional method is still applied and a push system is still employed in construction sites.

Questions 2 and 9, which represent the planning and control category, show that workers don't give their inputs regarding problems on the construction site. Some of the

respondents agreed that when they are faced with a problem they keep the problem as it is and others don't.

Q11 and Q20, which represent the quality category, had high variability in answers. This shows that some construction workers agreed that if they encounter a previously made task related to their work and done in the wrong way, they continue working on their job in a normal way. Some of the construction workers agreed that when they do a task it is okay if it is not up to the quality standards, they think it is only the job of the quality control to do so.

Table 5: Sign Test for Questions: Q8, Q2, Q9, Q10, Q19, Q34, Q40, Q11, Q20, Q6, Q15, Q24, Q30, Q31, Q36, Q39, and Q42

Question	Null Hypothesis (H0)	Sign test p-value	Decision	Discussion	Category
Q8	The population median of question 8 is equal to four	0.5386	Fail to reject H0	Extremely Weak	Kaizen
Q2	The population median of question 2 is equal to four	0.1882	Fail to reject H0	Extremely Weak	Planning & Control
Q9	The population median of question 9 is equal to four	0.8919	Fail to reject H0	Extremely Weak	Planning & Control
Q10	The population median of question 10 is equal to four	0.8991	Fail to reject H0	Extremely Weak	Pull Production
Q19	The population median of question 19 is equal to three	0.237	Fail to reject H0	Extremely Weak	Pull Production
Q34	The population median of question 34 is equal to four	0.3581	Fail to reject H0	Extremely Weak	Pull Production
Q40	The population median of question 40 is equal to three	1	Fail to reject H0	Extremely Weak	Pull Production
Q11	The population median of question 11 is equal to four	0.2	Fail to reject H0	Extremely Weak	Quality

Q20	The population median of question 20 is equal to four	0.8013	Fail to reject H0	Extremely Weak	Quality
Q6	The population median of question 6 is equal to four	0.321	Fail to reject H0	Extremely Weak	Standardization
Q15	The population median of question 15 is equal to four	0.5966	Fail to reject H0	Extremely Weak	Waste
Q24	The population median of question 24 is less than or equal to four	1	Fail to reject H0	Extremely Weak	Waste
Q30	The population median of question 30 is equal to three	0.496	Fail to reject H0	Extremely Weak	Waste
Q31	The population median of question 31 is equal to three	1	Fail to reject H0	Extremely Weak	Waste
Q36	The population median of question 36 is equal to four	0.1034	Fail to reject H0	Extremely Weak	Waste
Q39	The population median of question 39 is equal to three	0.435	Fail to reject H0	Extremely Weak	Waste
Q42	The population median of question 42 is equal to four	1	Fail to reject H0	Extremely Weak	Waste

The questions Q22, Q41, and Q5, which represent site organization, showed that most of the respondents scored a low results when addressing site organization concepts and practices. Construction workers agreed that materials can be stored everywhere on the construction site, organizing materials in pallets, bins and bags was a waste of time, and there was no need to keep the construction site clean.

Questions Q14 and Q23, which represent standardization, showed that most of the construction workers scored a poor result when it came to keeping only the required tools for doing their job in their corresponding working area and they didn’t follow a standardized way to perform their job.

Table 6: Sign Tests for Questions: Q33, Q4, Q22, Q41, Q5, Q14, and Q23

Question	Null Hypothesis (H0)	Sign test p-value	Decision	Discussion	Category
Q33	The population median of question 33 is equal to five	0.435	Fail to Reject H0	Poor	Planning & Control
Q4	The population median of question 4 is equal to five	0.3817	Fail to Reject H0	Poor	Quality
Q22	The population median of question 22 is equal to five	0.609	Fail to Reject H0	Poor	Site Organization
Q41	The population median of question 41 is equal to five	0.8013	Fail to Reject H0	Poor	Site Organization
Q5	The population median of question 5 is equal to five	1	Fail to Reject H0	Poor	Site Organization
Q14	The population median of question 14 is equal to five	0.169	Fail to Reject H0	Poor	Standardization
Q23	The population median of question 23 is equal to five	0.6029	Fail to Reject H0	Poor	Standardization

Questions Q12, Q16, and Q21, which represent safety, showed that most of the construction workers scored fairly when it came to safety. They somehow understand and practice safety procedures, follow safety signs and instructions, as well as they adequately use safety protections tools. This is due to the fact that safety in construction sites was the mostly applied and emphasized procedure assured in the general atmosphere in the construction site.

Questions Q26, and Q38, which represent Planning and Control, showed that most of the construction workers scored fairly when it came to organizing their daily work and receiving the required information to when, where, what should they do, and with whom.

Table 7: Sign Tests for Questions Q17, Q26, Q38, Q3, Q12, Q16, Q21, Q29, and Q35

Question	Null Hypothesis (H0)	Sign test p-value	Decision	Discussion	Category
Q17	The population median of question 17 is equal to six	0.7035	Fail to Reject H0	Fair	Kaizen

Q26	The population median of question 26 is equal to six	0.3817	Fail to Reject H0	Fair	Planning & Control
Q38	The population median of question 38 is equal to six	0.6089	Fail to Reject H0	Fair	Planning & Control
Q3	The population median of question 3 is equal to six	0.3891	Fail to Reject H0	Fair	Pull Production
Q12	The population median of question 12 is equal to six	0.899	Fail to Reject H0	Fair	Safety
Q16	The population median of question 16 is equal to six	0.7948	Fail to Reject H0	Fair	Safety
Q21	The population median of question 21 is equal to six	0.1619	Fail to Reject H0	Fair	Safety
Q29	The population median of question 29 is equal to six	0.8991	Fail to Reject H0	Fair	Standardization
Q35	The population median of question 35 is equal to six	1	Fail to Reject H0	Fair	Waste

Figure 5 shows the box plots for waste category. It is observed that almost all the questions related to the category of waste had a median less than 4.

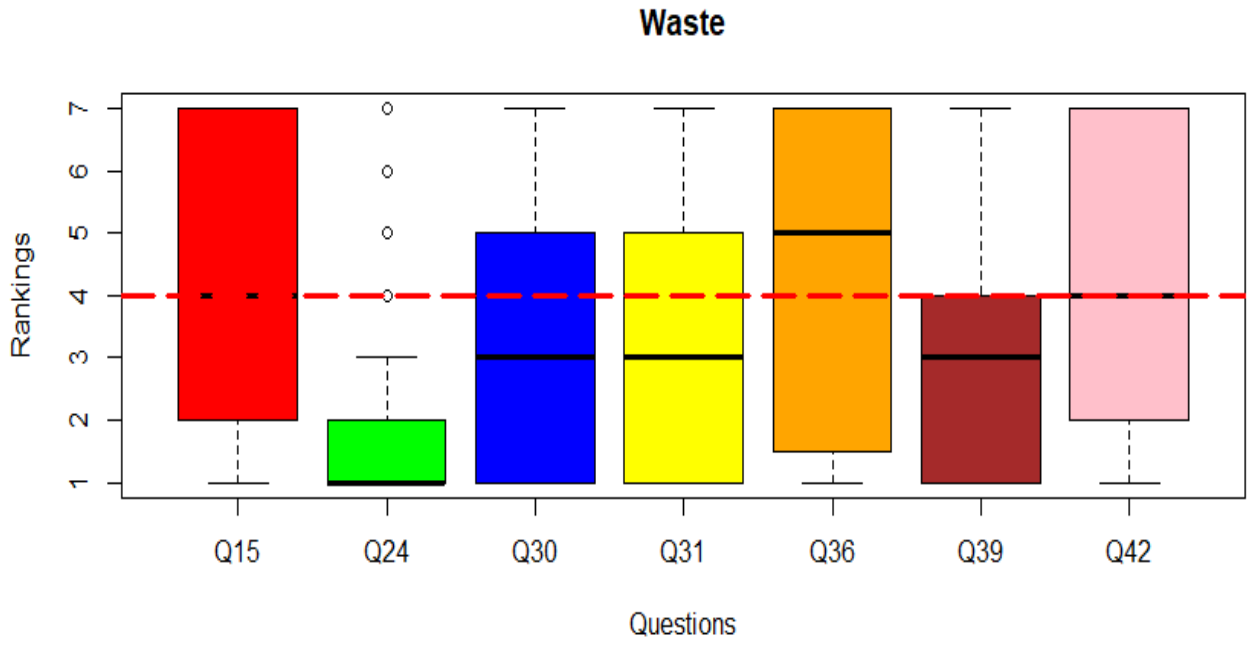


Fig. 5: Box Plot for Wastes

Figure 6 shows the boxplots of the questions related to standardization.

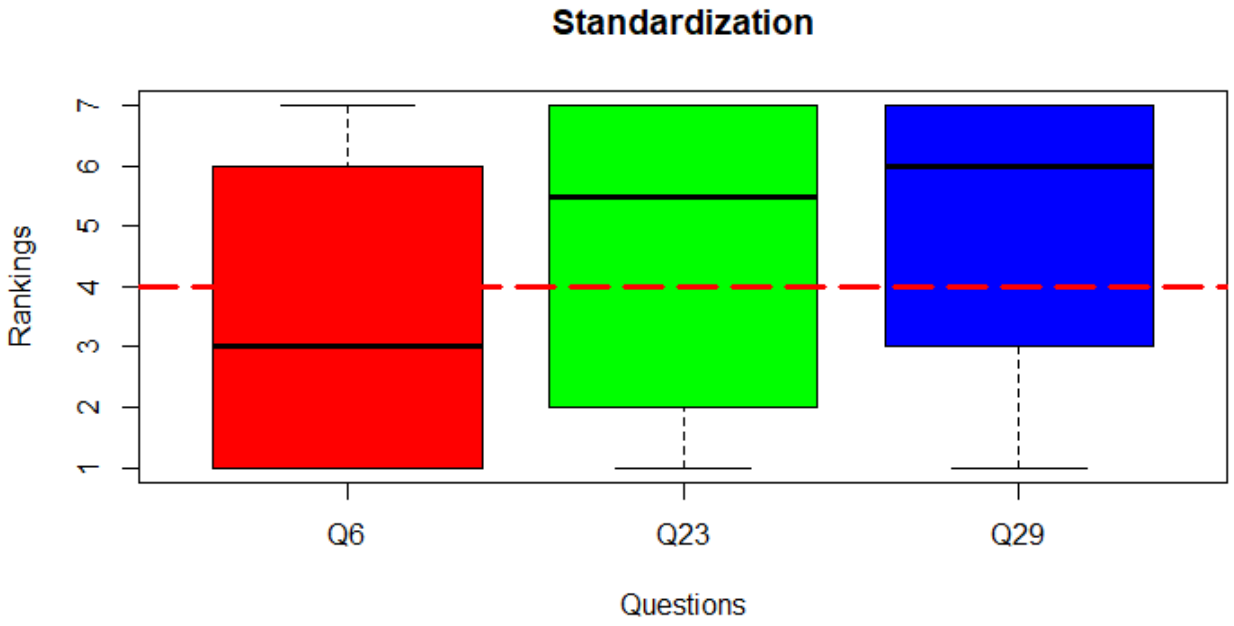


Fig. 6: Box Plot for Standardization

Figure 7 shows the boxplots for site organization. It is observed that almost all of the questions shows a median between 5 and 6.

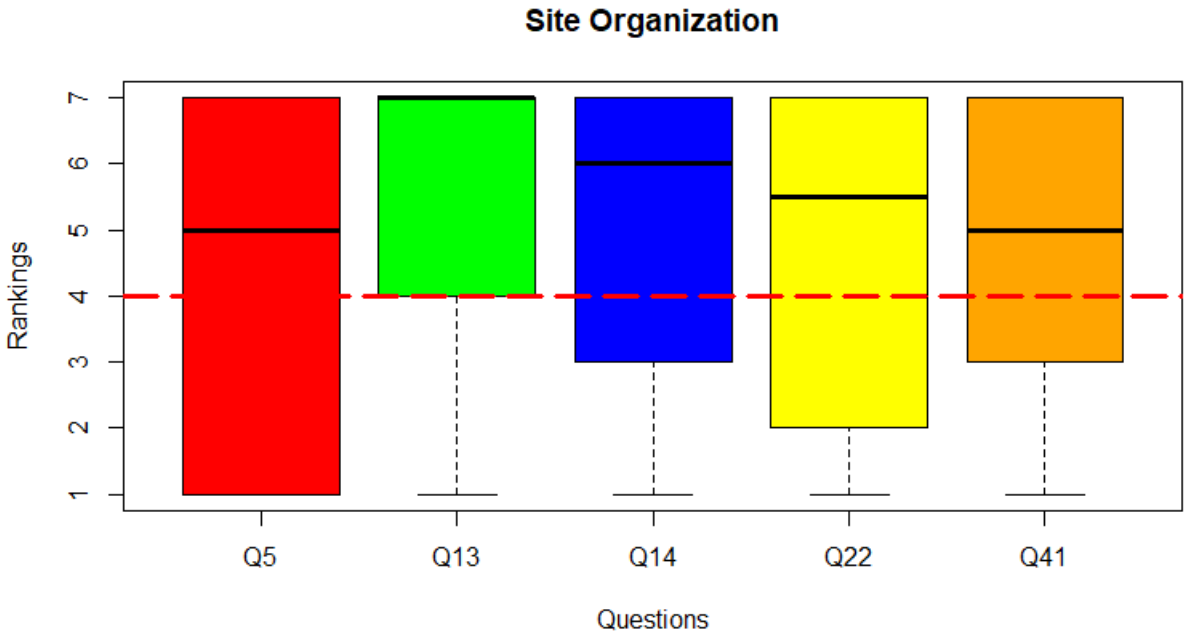


Fig. 7: Box Plot for Site Organization

Figure 8 shows the boxplots for the safety category. The results in the box plot confirm the previous analysis of the questions in table 7.

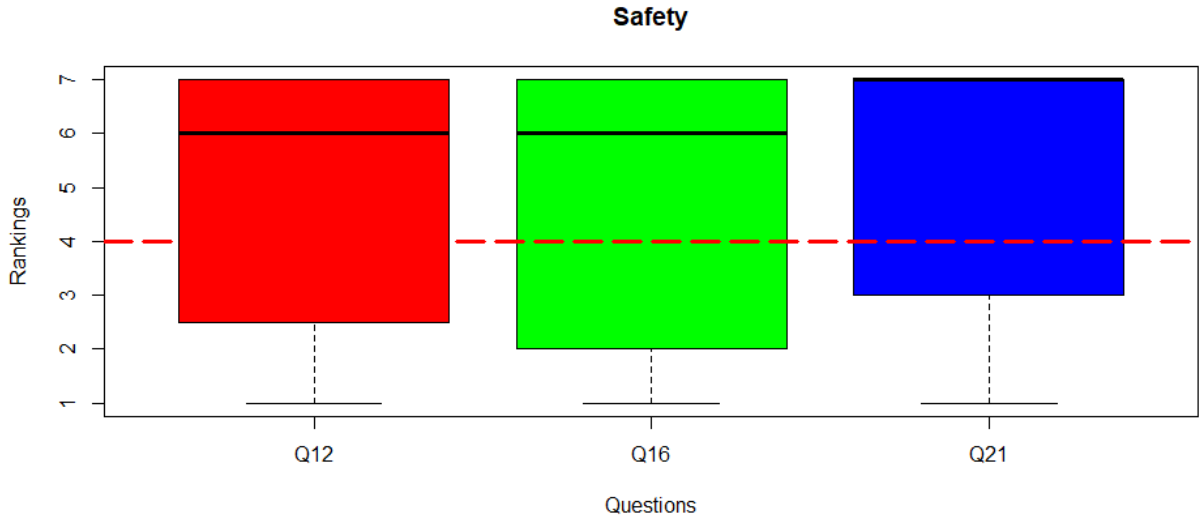


Fig. 8: Box Plot for Safety

Figure 9 shows the boxplots for the questions related to quality. It is observed that we have high variation for Q4, Q11 and Q20.

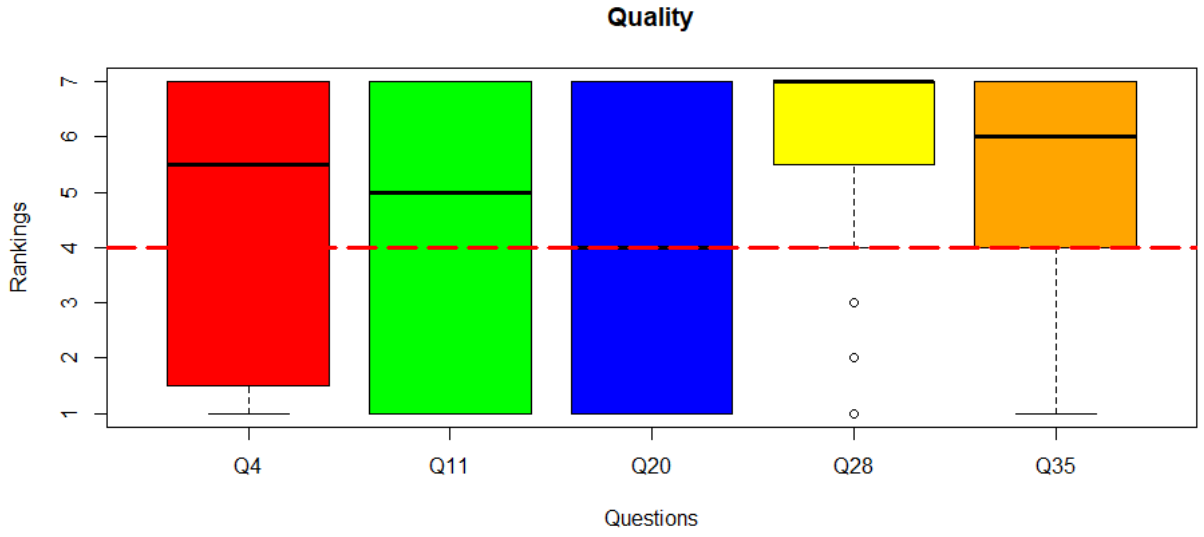


Fig. 9: Box Plot for Quality

Figure 10 shows the boxplots for questions related to pull production. It is clearly observed that mostly all the questions have scored less than 4.

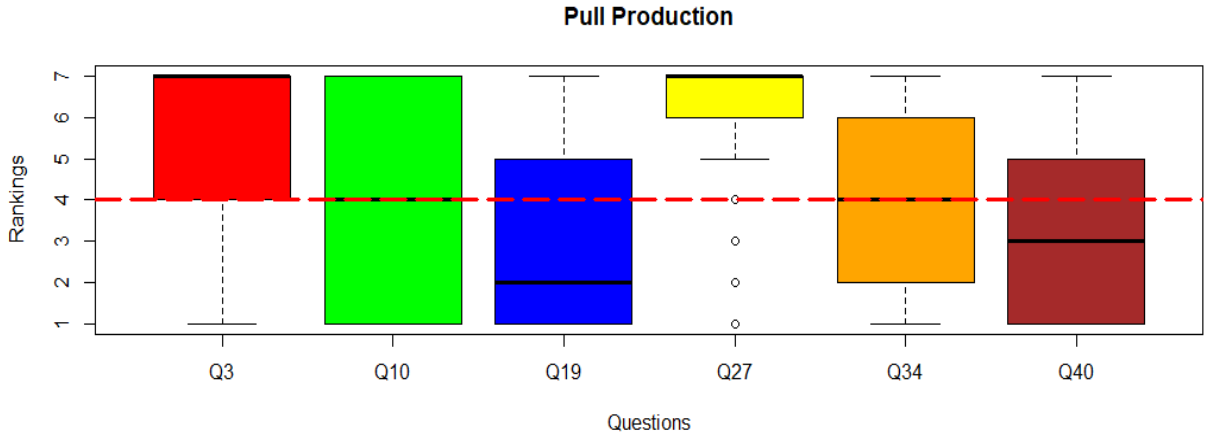


Fig. 10: Box Plot for Pull Production

Figure 11 shows the boxplots for the planning and control.

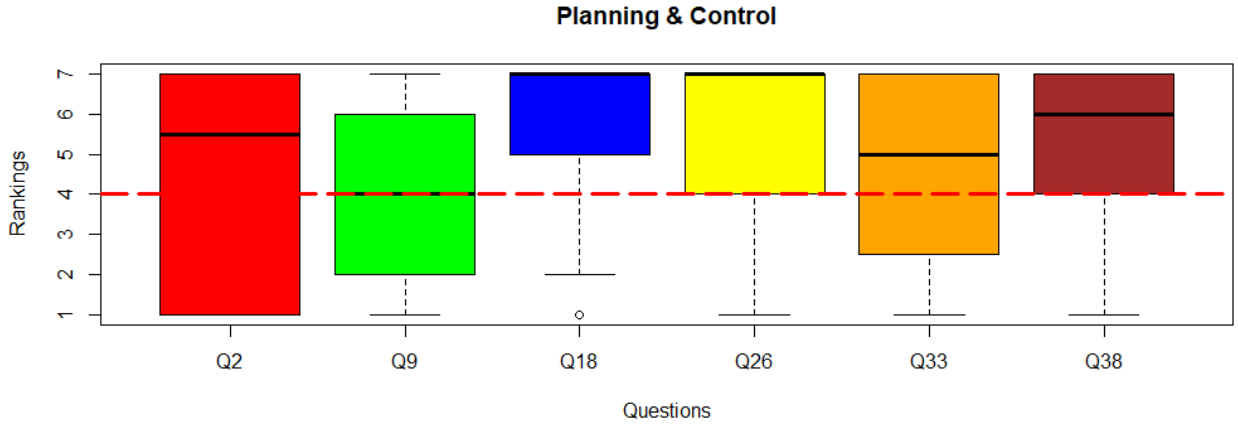


Fig. 11: Box Plot for Planning and Control

Figure 12 shows the box plots for kaizen related questions. It is observed that construction workers scored high results for this category.

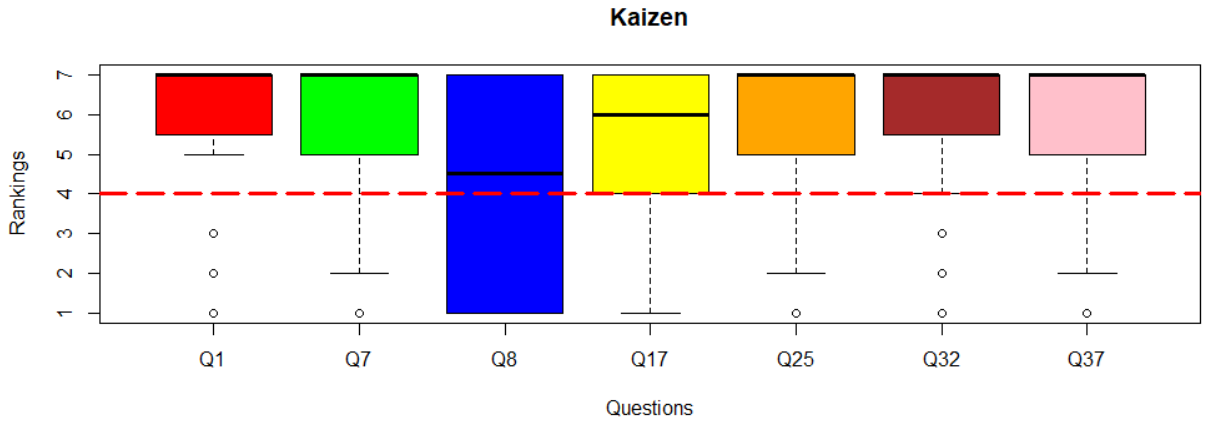


Fig. 12: Box Plot for Kaizen

B. Analyzing the Eight Categories of Lean Knowledge Profile in Construction for Construction Workers:

Each question in the survey was related to one of the eight categories of the lean construction knowledge as mentioned in section 5.1 and as shown in table 3. First these questions were categorized into category, then the average score per category for each respondent was calculated. The average answers for the 73 respondents in the eight categories are shown in table 8, where K represent Kaizen, PC: Planning and Control, PP: Pull Production, Q: Quality, SA: Safety, SO: Site Organization, ST: Standardization, W: Waste.

Table 8: The average answers per respondent for each category

	K	PC	PP	Q	SA	SO	ST	W
R1	2.14	1.83	1.33	0.2	1	2.6	0.33	0.57
R2	3.29	4.83	3	3.6	3.67	3.6	4	2.43
R3	3.29	2.17	4.67	5.2	0.67	3.6	5	2
R4	4.57	4.5	5.5	4.6	7	5	2.67	3.86
R5	6.57	5	5	3.4	1	4.2	5	2.71
R6	5	5.17	4.33	3.4	7	2.4	1	2.86
R7	6.57	6.5	5	5.4	4.33	4.4	3.67	5
R8	3.57	2	2	2.8	0	1	1.67	1.86

R9	7	5.33	3.17	6.8	6.67	4.2	5.67	3.86
R10	6.71	4.33	3.83	4.6	5	5	4.33	1
R11	4.57	5.83	4.17	4.4	2.33	3.6	3.67	4.43
R12	1.14	1.17	1.17	0	0	0.2	2.67	0.14
R13	4.43	5	4.33	2.6	2.67	3.8	2.67	2.43
R14	6.71	5.67	5	4.4	7	5.8	7	2.57
R15	4.71	3.5	3.17	3	0	2.8	2.67	2.71
R16	4.71	5.67	4.83	5	6	4.6	5	3.29
R17	5.86	5.17	5.33	5.6	7	5.4	2.67	4.43
R18	5.14	5.17	4.17	3.6	6	6.2	3.67	3
R19	6.71	7	4.17	7	7	5.8	2.67	4
R20	6.86	7	5	3.8	6.33	6.2	5	2.57
R21	5.14	5.33	4.33	5	4.33	4.6	5.67	4.43
R22	5.29	4.83	3.5	4.6	1.33	2	4.33	4.57
R23	6.14	5.67	4.17	5.8	6.67	5	5.33	2.43
R24	7	4.33	5	6.8	4	6	4.67	3.43
R25	3.86	3.67	3.5	2.8	7	1.6	1.33	1.14
R26	3.43	4.83	4.67	2.8	3.67	5	2.67	2.71
R27	6.86	6.5	4	5	3.33	6.2	3	4.29
R28	4.71	4.33	4.17	6.4	7	5	2.67	3.71
R29	6	4.33	3.67	4.8	7	5.6	3.33	2.86
R30	5.43	5.33	5	4.2	5.33	4.6	4	5.57
R31	5.71	5.33	5.67	6.8	6.67	6.4	3	3.29
R32	5.14	4.83	4.17	4.6	3	3	5.33	2.43
R33	6.14	6.17	3	4.6	6	5.8	5	1.86
R34	3.86	2	1.17	3.6	0	0.4	2.67	3
R35	2.29	1.17	1.17	3	0	1.2	3.67	1.29
R36	6.86	5.83	5.33	5	7	6	5.33	3.43
R37	5.86	6	4.83	5	7	7	6.33	3.86
R38	4	3	5.17	2.6	3	4.8	4.33	2.86
R39	7	6.5	4.83	5.8	7	5.8	4.67	4.43
R40	4.43	3.5	5.17	2.8	2.33	3.2	3	2.86
R41	7	6.67	3.5	3.8	3.67	5.6	4.33	3.43
R42	6.14	4.33	5.5	4	7	6.6	6	5.29
R43	7	6.5	4.67	5.8	7	6	7	4
R44	7	6	5.67	6.8	7	6.6	5	4.43
R45	5.71	3.83	4	6	5.33	3.8	6.67	4.86
R46	6.14	4.67	4.17	6.6	4.33	6.6	4.33	4.57
R47	7	6	3.5	6.8	7	4.6	5.67	3.57
R48	5.57	3.5	3.33	3.4	4	3	4.67	3.86
R49	5.86	5.67	4.83	6.8	1	4.8	4	1.86
R50	6.14	5.5	3	5.8	5	4.6	5	1.71
R51	4.86	4.67	2.17	4.6	3	3.4	4	1.14
R52	5	5.5	6	4.6	6.67	4.4	5.67	2.14
R53	6.14	3.33	3.5	2.8	4	4.6	6.33	1.71
R54	4	3.17	3.17	3.4	4	3.8	1.67	4.14
R55	4.57	3.5	3.67	4.6	2.33	3	3	2.43
R56	7	5.17	4.83	4.8	4.67	4.4	4.33	4.29

R57	6.86	5.83	5.17	5.8	2.67	4.4	5.67	3.71
R58	4.71	5.5	4.67	4.2	4	7	4.33	3.14
R59	3.57	2.5	3.33	4	4.67	4.8	3	4.86
R60	4.29	3.83	2.5	4.6	3	3	5	1.86
R61	4.43	5	3	3.4	3	7	5	3.71
R62	6.14	4	5	5.6	5.33	2.4	5	1
R63	4.43	5	4.17	3.4	3	3.4	1.33	4.43
R64	5.86	2.83	4.33	4.6	5	4	2.67	4.29
R65	3.57	1.5	3	5.8	3	5.2	5	5.29
R66	1.86	3	3	3.8	6	4.2	3	3.14
R67	2.57	2.17	4	7	7	3.8	1.33	2.86
R68	3	3.67	4.17	4.6	5	4.2	3	4.43
R69	5	4.33	2.33	1.8	5	3.2	2.33	2.86
R70	6	6.33	4.17	6.6	6	6.4	6	3.57
R71	5.57	6.33	5.17	6.6	6	5.8	6	3.43
R72	4.43	4	2.83	3.6	6.67	2.6	3.67	3.71
R73	6	6.33	4.33	6.8	6	7	6	3.43

The respondent averages were statistically analyzed in order to establish if the eight categories were significantly different from each other. The non-parametric test Kruskal-Wallis rank sum test was used. The null hypothesis was that there was no difference across the eight categories=. The p-value obtained from the Kruskal- Wallis test is 2.895e-13 which indicates that there is enough evidence to indicate that at least one of the eight categories was different from the others.

In order to know which groups were significantly different from the others, the pairwise Wilcoxon rank sum test with holm adjustment p-value was used. The Wilcoxon signed rank test was used to test the null hypothesis that the median difference between two categories was equal to zero. The results of the pairwise Wilcoxon rank sum test for the eight categories are represented in table 9:

Table 9: P-values for the Pairwise Wilcox Test for differences between the 8 lean categories

	K	PC	PP	Q	SA	SO	ST

PC	0.27786						
PP	6.2e-06	0.03445					
Q	0.18319	1	0.34956				
SA	1	1	0.46244	1			
SO	0.08037	1	0.52397	1	1		
ST	0.00046	0.37103	1	0.64305	0.64305	1	
W	3.4e-12	2.4e-7	0.00096	7.2e-7	0.00046	1.8e-5	0.00712

Table 9 shows that:

- K and PP, K and ST, K and W: Construction workers know more about Kaizen than Pull Production, Standardization, and Waste.
- PC and PP, PC and W: Construction workers know about Production and Control more than they know about Pull Production and Waste.
- PP and W: Construction workers know about Pull Production more than they know about Waste.
- Q and W: Construction workers know about Quality more than they know about Waste.
- SA and W: Construction workers know more about Safety than Waste.
- SO and W: Construction workers know more about Site Organization than Waste.
- ST and W: Construction workers know more about standardization than Waste.

As a result, table 9 shows that waste was the least known category for construction workers in comparison to the other seven categories. Pull production was as well the least known category for workers in comparison to the other six categories except for waste and

planning and control. Figure 13 shows the boxplot for the eight categories of lean construction knowledge profile. It compares the eight categories together.

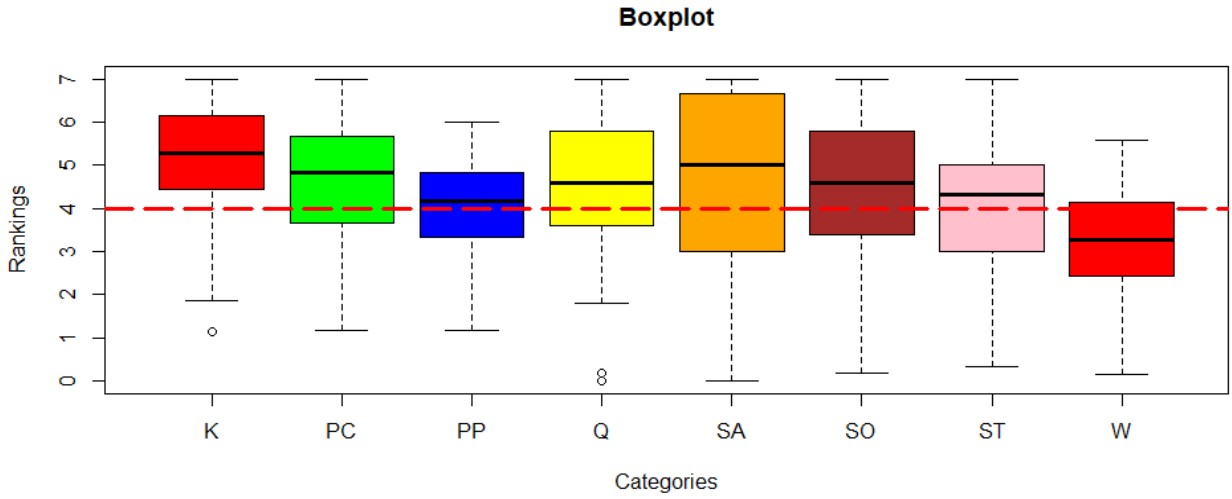


Fig. 13: Boxplot for the Eight Categories of Lean Knowledge Profile

The above boxplot that represent the eight categories confirmed again our previous findings which showed that Waste scored the worst category among the others. In addition, Pull Production, Planning and Control, Standardization, Site Organization and Quality scored a median very close to 4. This shows that construction workers have little knowledge regarding these concepts. Kaizen scored high due to the bias in the responses of the construction workers. Construction workers have general idea about the importance of using helmets, and protective equipment.

All the answers of the respondents to each of the questions related to the categories were gathered and a histogram that shows the percentage for each value on the Likert scale was observed and plotted.

CHAPTER VIII

RECOMMENDATIONS AND OBSERVATIONS

A. Recommendations to address the areas of weaknesses in lean construction understanding

After analyzing the results of each question and the overall categories in the survey, the following recommendations were developed.

First, construction workers showed mainly a lack of knowledge in the areas of waste, pull production and planning and control. As a result, construction workers must receive training in all categories of lean construction, with strong emphasis on those three categories. Training games demonstrate lean construction principles and concepts in action. Games allow construction workers to get involved and engaged in the learning process. The training games help construction workers implement their lean roles properly, understand the lean construction concepts, and fully integrate the lean construction knowledge profile. In order to come up with table 10, the following procedure was performed:

1. Different lean games that target lean manufacturing and lean construction were investigated. Out of these games only the ones that tackle construction were identified and in particular the ones that construction workers can relate to i.e. the ones which fall into the eight categories and the lean knowledge profile.
2. The lean areas that every game address were identified. Then, each area was linked to the eight categories previously mentioned before.

3. The table matches the games with the areas of weaknesses found in the study, which are mainly: waste, pull production and planning and control.

The selected games along with their corresponding contribution to lean construction concepts are given below in table 10. For more information about the lean games found in table 10, please check section 10.

Table 10: The Lean Games and Their Corresponding Category

	Categories					
Games	**Site Organization**	**Waste**	**Kaizen**	**Standardization**	**Planning and Control**	**Quality**
House of Cards	X	X	X		X	
Standard Pig Game	X	X	X	X		X
5s Numbers	X		X			
Ball Game	X		X			
Dollar Game			X			
Broken Squares			X		X	
Leapcon		X		X		
Parade Game						
Airplane Game			X	X	X	X
Maroon White Game			X		X	X
Dice Game					X	
Win As Much As You Can			X		X	
Villego			X	X	X	
Lebsco			X	X	X	
Marshmallow Simulation			X			

Deming's Red Bead Game					**X**	**X**
Paper Airplane Game						**X**
Helium Stick Game			**X**			
Pipes and Marbles			**X**			
Binniger's Takt Game		**X**				
InFrame		**X**	**X**			
Last planner Driven Game			**X**	**X**	**X**	**X**
Lean Apartment Simulation Game		**X**				
Lean Cups Game/ Dot Game						
Make a Card						
Kanban pizza Game					**X**	
Marshmallow TVD Game			**X**			
Delta Design Game			**X**			
Lego Game			**X**			
The Lean Lemonade Tycoon 2			**X**			

Second, according to the construction sites interviews', the skilled workers remain with the same contractors from project to project. These skilled workers should be the ones to be given the training exercises and practices in the construction site. In return, these skilled workers will give the other workers the required training exercises. In other words, each contractor should have a core team of skilled and trained construction workers.

Third, construction workers who work in manufacturing construction related products such as aluminum works, doors, etc. have a certain kind of continuity in the workplace. This might help in changing the contract type of employment from daily or weekly to monthly, thus making them somehow constant workers who might get training, benefit from it and still remain in the same company. Such workers are a good long term investment for the company in lean construction.

Fourth, introducing lean construction concepts should be done through recognizable realistic situations in training exercises. Skilled and trained construction workers should be the "role models" for the other construction workers. Two way communication, team work, and a "no blame" environment should be the prevailing attitude in the construction site.

B. Observations

In this section, the author will discuss the observations encountered throughout the site visits. Those observations were made while conducting the surveys for this study.

First, it was clearly observed that no training is given for construction workers, where only engineers, foremen and general contractors are the center of the focus. There is a focus mainly on the training and developing of engineers, project managers, and general foremen. For example: only general foremen in construction sites were trained to face safety related procedures, such as: fire hazards, and given emergency response trainings.

Second, construction workers might have heard about safety practices, and the other lean concepts mainly from the implementation of ISO standards in certain companies. This explains the somehow the current limited knowledge regarding such practices. In addition, they might have heard of such practices from other construction sites and from the engineers

on sites. But these safety standards are only the basics, for example, other safety regulations like: working at heights and wearing high visibility jackets are being ignored.

CHAPTER IX

CONCLUSIONS

One of the pillars of lean construction are the people and partners. Involving all the personnel on and off the construction site is vital for harnessing the full benefits of lean, and these personnel need to be trained about the lean construction principles. Lean construction induces new roles, responsibilities and knowledge for construction workers. The author recognized eight main categories that construction workers should know, understand and practice on the construction site, which are: pull production, planning and control, site organization, safety, quality, standardization, kaizen and waste. Based on these categories, a detailed lean construction worker knowledge profile was conducted. The main focus of this study was to develop a tool to assess and enhance the workers understanding of lean concepts. The assessment was made through a questionnaire which took place in several construction sites in Lebanon. After analyzing the results of the questionnaire, the author concluded that construction workers have a general lack of knowledge regarding the lean construction knowledge profile. The following results were obtained:

Construction workers suffer from a lack of understanding and applying waste related concepts and their types, an absence of lean pull production practices and knowledge, in addition to not showing responsibility for the jobs they are doing.

General lack of understanding site organization and standardization concepts. Construction workers are not strong believers of these concepts. They may support them but they don’t strongly believe or understand the importance of applying them. These areas are somehow as well related to the overall organization/ company’s concepts and practices regarding lean construction.

Construction workers are not engaged in the planning and control of the construction activities and the construction site. They don’t give feedback on the progress of their work. This is clearly obvious in the traditional construction methods that is still applied in many construction sites in Lebanon.

CHAPTER X

RESEARCH LIMITATIONS

In Lebanon, surveys are not a common practice. The use of surveys has its positive and negative aspects. Here are some of the limitations related to the survey:

Lack of trust in the anonymity of the information collected fearing that the provided information might get into the hands of the management of the company.

Dishonesty in responding to the questionnaire is another obstacle which was clearly observed in the Kaizen related questions, where respondents tried to protect their privacy and tended to have social desirability bias.

Construction workers were anxious about the anonymity of the research and as a result were afraid that such an assessment might have negative consequences on their jobs at the construction site. In addition, some contractors were afraid that such as assessment of the construction workers might induce a negative image for their work, as a result they refused to take part in this survey. This is despite our continuous assurance that the survey will be anonymous and that the target is not the company but the construction workers.

Throughout the interviewing process, the author repeatedly emphasized the anonymity of the research. However, construction workers were influenced by a fear of management reprisal.

Construction workers answers mainly varied between 1 and 7, which are entirely agree or entirely disagree. The 1 to 7 Likert scale which includes 1: entirely disagree, 2: mostly disagree, 3: somewhat disagree, 4: neither agree nor disagree, 5: somewhat agree, 6: mostly agree, 7: entirely agree, had a wide range of variances and using 1 to 5 could have

been more flexible for construction workers to use and understand. But on the other hand, studies that has a 1-7 Likert scale typically show better results and sprea

CHAPTER XI

SURVEY DATA

A. R CODE

```
#loading the data from the excel sheet

Library(readxl)

For_r_studio<- read_excel("C:/Users/Lenovo/Downloads/research_documents/for r studio.
xlsx")

#Boxplots
boxplot(x=NumberData, names=BoxLabels, main= "Kaizen", xlab="Questions", ylab="Ra
nkings", boxfill=boxfillcolors)

abline(h=4, lty=5, col="Red",lwd=3 )

boxplot(x=NumberData1, names=BoxLabels1, main= "Planning & Control", xlab="Questi
ons", ylab="Rankings", boxfill=boxfillcolors)

abline(h=4, lty=5, col="Red",lwd=3 )

boxplot(x=Numberdata2, names=Boxlabels2, main= "Pull Production", xlab="Questions",
ylab="Rankings", boxfill=boxfillcolors)
abline(h=4, lty=5, col="Red",lwd=3 )


boxplot(x=Numberdata3, names=Boxlabels3, main= "Quality", xlab="Questions", ylab="R
ankings", boxfill=boxfillcolors)
abline(h=4, lty=5, col="Red",lwd=3 )


boxplot(x=Numberdata5, names=BoxLabels5, main= "Safety", xlab="Questions", ylab="R
ankings", boxfill=boxfillcolors)
abline(h=4, lty=5, col="Red",lwd=3 )


boxplot(x=NumberData6, names=Boxlabels6, main= "Standardization", xlab="Questions",
ylab="Rankings", boxfill=boxfillcolors)
abline(h=4, lty=5, col="Red",lwd=3 )
```

```
boxplot(x=Numberdata7, names=Boxlabels7, main= "Waste", xlab="Questions", ylab="Ra
nkings", boxfill=boxfillcolors)
abline(h=4, lty=5, col="Red",lwd=3 )


boxplot(x=Numberdata10,names=BoxLabels10, main="Boxplot", xlab="Categories", ylab
="Rankings", boxfill=boxfillcolors) #boxplot for the 7 categories

abline(h=4, lty=5, col="Red",lwd=3 )

# One Sample Sign t-test

If(!require (BSDA)){install.packages("BSDA")}
If(!require(DescTools)){install.packages ("DescTools")}
library(BSDA)

SIGN.test(For_r_studio$Q8, md=4, alternative=" less")



Install.packages("reshape2") # convert the data between long and wide format

Library(reshape2)

mdata<-melt(For_categories)

Head(mdata)

pairwise.wilcox.test(mdata$value, mdata$variable,p.adj="holm")
```

B. ENGLISH SURVEY

American University of Beirut

Maroun Semaan Faculty of Engineering and Architecture

Department of Civil and Environmental Engineering

Thesis Advisor: Professor Farook Hamzeh

Organized by: Rania Albanna

Survey

Thank you for participating in this survey. The objective of this questionnaire is to know the views of the work force about the construction site in order to study the construction management practices. This survey is expected to take 10 minutes to complete.

Note: All the answers you provide remain in absolute secrecy and are only used to form a field research for this study. The survey answers will be randomly collected. Please do not write your name on this survey paper.

☐ **Skilled worker** ☐ **Non Skilled Worker**

Years of Experience: ……

Please respond to the following questions by selecting on a scale from 1 to 7:

1- **Entirely disagree / 2- Mostly disagree / 3- Somewhat disagree / 4- Neither agree nor disagree /5- Somewhat agree /6- Mostly agree /7- Entirely agree**

Q1.	I review my work mistakes with the foremen, and I suggest preventive measures to avoid its occurrence in the future.	Select 1/2/3/4/5/6/7
Q2.	When faced with a problem, I leave it as it is.	Select 1/2/3/4/5/6/7
Q3.	I know the time I take to complete a certain task.	Select 1/2/3/4/5/6/7
Q4.	If I'm in a hurry, I prefer to sacrifice quality over time.	Select 1/2/3/4/5/6/7
Q5.	There is no point in keeping the working area clean and tidy because it will get dirty again.	Select 1/2/3/4/5/6/7
Q6.	In our company, each foremen execute the same task using their own different methods.	Select 1/2/3/4/5/6/7
Q7.	If I found a better way to perform a task, I show the fellow worker how to do it.	Select 1/2/3/4/5/6/7
Q8.	There is no point in knowing the causes of a problem at the construction site because we will often face problems.	Select 1/2/3/4/5/6/7
Q9.	We are too busy working we don't even have time to review why a planned activity was not accomplished.	Select 1/2/3/4/5/6/7
Q10.	If I give a promise that I will finish my work on a certain date, it's ok if I delayed it one, two or three days.	Select 1/2/3/4/5/6/7
Q11.	When I encounter a previously made task related to my work that was done in a wrong way, I continue working on my job in a normal way.	Select 1/2/3/4/5/6/7
Q12.	I am very focused on my work in a way that I forget about the safety signs.	Select 1/2/3/4/5/6/7
Q13.	It is better if everything is marked on the construction site, for example, location of tools, material unloading, floor path markings, waste bins…	Select 1/2/3/4/5/6/7
Q14.	In a certain working area, I only keep the materials and tools that I use for performing my task in that area and nothing else.	Select 1/2/3/4/5/6/7
Q15.	I think that unloading large quantities of materials not immediately required at the construction site is quite good.	Select 1/2/3/4/5/6/7
Q16.	If I'm in a hurry, it's okay if I don't wear the safety helmet.	Select 1/2/3/4/5/6/7
Q17.	I always try to find the root cause of a mistake I made.	Select 1/2/3/4/5/6/7

Q18.	I think there should be a set of work rules that everyone should abide by and those rules should be clear for everyone.	Select 1/2/3/4/5/6/7
Q19.	It's ok if sometimes we are busy with lots of work to do and at other times we have lack of work.	Select 1/2/3/4/5/6/7
Q20.	When I do a task, it’s ok if it is not up to the quality standards. It's the job of the QC.	Select 1/2/3/4/5/6/7
Q21.	There is a mess on the construction site, so I think there is no purpose for having clear and protected paths on site.	Select 1/2/3/4/5/6/7
Q22.	I think materials can be stored throughout the site, in the building, on the roof, in different rooms, on the site and in the corridors.	Select 1/2/3/4/5/6/7
Q23.	There is a standardized procedure to do a task.	Select 1/2/3/4/5/6/7
Q24.	If I do not have any work to do, I can still find a preparatory job to do.	Select 1/2/3/4/5/6/7
Q25.	I introduce new suggestions and ideas on how to do my task.	Select 1/2/3/4/5/6/7
Q26.	I organize what I do every day and I have my plan of doing my work.	Select 1/2/3/4/5/6/7
Q27.	I think reliable promising is an important value which should be respected and everyone on the construction site should stick to it.	Select 1/2/3/4/5/6/7
Q28.	I try my best to do the task right the first time even if it takes more time to do it.	Select 1/2/3/4/5/6/7
Q29.	I think that if I follow the same procedures to do a task I will get same results every time.	Select 1/2/3/4/5/6/7
Q30.	When I work at the construction site, I leave the construction waste until the task is completed then I collect them instead of cleaning as I go.	Select 1/2/3/4/5/6/7
Q31.	I can start a task even if all its prerequisites are not ready.	Select 1/2/3/4/5/6/7
Q32.	I think there is always a room for improvement in the way I do a task.	Select 1/2/3/4/5/6/7
Q33.	The foremen gives me my weekly work schedule at the beginning of the week.	Select 1/2/3/4/5/6/7
Q34.	It’s okay if different crews who work on different jobs are present in the same working area while using different materials.	Select 1/2/3/4/5/6/7

Q35.	I do in process inspection for the task I regarding quality.	Select 1/2/3/4/5/6/7
Q36.	I think I can minimize the number of steps to do a process.	Select 1/2/3/4/5/6/7
Q37.	Everyone in the company emphasizes the importance of applying the company's values and goals.	Select 1/2/3/4/5/6/7
Q38.	The foremen provides us with all the information required to do our job such as what we should do, when, where and with whom.	Select 1/2/3/4/5/6/7
Q39.	It's ok if we waited for the materials either to arrive to the construction site or to change its position.	Select 1/2/3/4/5/6/7
Q40.	I think it is pretty fine to disrupt my work on a certain task to do another task and get back to it after a certain time.	Select 1/2/3/4/5/6/7
Q41.	Organizing construction materials and tools in bins, standard pallets and bags is a waste of time.	Select 1/2/3/4/5/6/7
Q42.	I usually spend some time every day searching for materials, equipment or information.	Select 1/2/3/4/5/6/7

Thank you

C. ARABIC SURVEY

الجامعة الأميركية في بيروت

كلية الهندسة

قسم الهندسة المدنية

مستشار الأطروحة: الدكتور الجامعي فاروق حمزه

اعداد: الطالبة رانيا البنا

استطلاع

شكراً لكم لموافقتكم على المشاركة في هذا الاستطلاع. إنَ الهدف من الأسئلة التالية هو معرفة آراء ذوي الخبرة الميدانية فيما يتعلق بموقع البناء، وذلك من أجل دراسة ادارة المنشأت. من المتوقع أن يستغرق هذا الاستطلاع 10 دقائق فقط لإكماله.

ملاحظة: إن جميع الإجابات التي تقدمها تبقى في سرية مطلقة ,ولا تستخدم إلا في تشكيل مرجع ميداني لهذه الدراسة.

سيتم جمع إجابات الإستطلاع بشكل عشوائي. من فضلك لا تكتب اسمك على ورقة الإستطلاع.

معلم ☐ **عامل** ☐

عدد سنوات الخبرة : .....

يرجى الرد على الأسئلة التالية عن طريق تحديد مقياس من 1 إلى 7

1- لا أوافق تماماً 2- لا أوافق في الغالب / 3- لا أوافق إلى حد ما / 4- لا أوافق ولا أرفض / 5- أوافق إلى حد ما / 6- أوافق في الغالب / 7- أوافق تمامًا

1.	أراجع أخطائي في العمل مع "الفورمن" , وأقدم اقتراحات وقائية لتجنب حدوث أخطاء مشابهة في المستقبل.	1/2/3/4/5/6/7
2.	عندما أواجه مشكلة ما, أترك المشكلة كما هي.	1/2/3/4/5/6/7
3.	أعرف الوقت الذي أحتاجه لإنجاز عملي.	1/2/3/4/5/6/7
4.		

5.	إذا كنت في عجلة من أمري أفضل أن أضحي بالجودة على حساب الوقت	1/2/3/4/5/6/7
6.	ليس هناك جدوى من الحفاظ على نظافة منطقة العمل وترتيبها لأنها سوف تتسخ مرة أخرى	1/2/3/4/5/6/7
7.	في شركتنا ، كل "فورمن" يقوم بتنفيذ العمل نفسه بطريقته الخاص	1/2/3/4/5/6/7
8.	إذا وجدت طريقة أفضل للقيام بعمل ما, أوضح للعامل كيفية إنجازه.	1/2/3/4/5/6/7
9.	لا جدوى من معرفة سبب حدوث مشكلة ما في موقع البناء لأننا غالباً سنواجه مشاكل	1/2/3/4/5/6/7
10.	نحن مشغولون كثيراً لدرجة انه ليس لدينا وقت كاف للبحث عن أسباب عدم التمكن من انجاز مهمة مخطط لها مسبقاً	1/2/3/4/5/6/7
11.	إذا أعطيت وعدًا بإنجاز عملي في يوم محدد ، فلا بأس إذا تأخرت يوماً أو يومين أو ثلاث.	1/2/3/4/5/6/7
12.	إذا وجدت عملاً سابقاً مرتبطاً بعملي قد أنجز بطريقة خاطئة, أنهي العمل المطلوب مني بشكل طبيعي.	1/2/3/4/5/6/7
13.	أركز كثيراً في عملي لدرجة تجعلني انسى علامات السلامة	1/2/3/4/5/6/7
14.	من الأفضل إذا تم وضع إشارة لكل شيء في موقع البناء ، على سبيل المثال إشارة لموقع الأدوات ، ومكان تفريغ المواد ، وعلامات المسارات ،وصناديق النفايات	1/2/3/4/5/6/7
15.	في مكان عملي ، أحتفظ فقط بالمواد والأدوات التي أستعملها لأداء مهمتي في هذا المكان ولا شيء آخر	1/2/3/4/5/6/7
16.	أعتقد أن وضع كميات كبيرة من المواد غير المطلوبة حالياً في موقع البناء أمر جيد	1/2/3/4/5/6/7
17.	إذا كنت في عجلة من أمري لا بأس إذا لم أضع خوذة السلامة	1/2/3/4/5/6/7
18.	اسعى دائماً لمعرفة السبب الجذري وراء خطأ ما ارتكبته	1/2/3/4/5/6/7
19.	أعتقد أنه يجب أن تكون هناك مجموعة من قواعد العمل الواضحة والملزمة للجميع	1/2/3/4/5/6/7
20.	لا بأس اذا كان لدينا عمل كثير في أوقات معينة ، وفي أوقات أخرى عمل قليل	1/2/3/4/5/6/7
21.	لا بأس إذا كان عملي لا يتوافق مع معايير الجودة لأن التدقيق من مهام مراقب الجودة .	1/2/3/4/5/6/7

22.	يوجد فوضى في وقع البناء لذلك ليس من الضروري وضع علامات واضحة ومسارات محددة في الورشة	1/2/3/4/5/6/7
23.	أعتقد أن مواد البناء يمكن وضعها في كل مكان في الورشة وفي البناية وعلى السطح وفي مختلف الغرف و في الرواق	1/2/3/4/5/6/7
24.	هناك إجراء موحد للقيام بعمل ما	1/2/3/4/5/6/7
25.	إذا لم يكن لدي أي عمل أقوم به ، يمكنني القيام بعمل تحضيري	1/2/3/4/5/6/7
26.	غالباً ما أبحث عن أفكار وطرق جديدة لتأدية عملي	1/2/3/4/5/6/7
27.	أنظم عملي اليومي وأضع خطة لإنجازه	1/2/3/4/5/6/7
28.	أعتقد أن الوعد وكلمة الثقة هما قيمتان مهمتان في التعاطي بين جميع العمال والمهندسين والمسوؤلين في الورشة	1/2/3/4/5/6/7
29.	أحاول جهدي القيام بمهمة ما بشكل صحيح حتى لو تطلبت وقتاً إضافياً	1/2/3/4/5/6/7
30.	أعتقد أنه إذا اتبعت الخطوات نفسها للقيام بعمل ما ، سوف أحصل على النتائج نفسها كل مرة	1/2/3/4/5/6/7
31.	أترك مخلفات البناء حتى اكمال المهمة ثم أقوم برميها بدلاً من القيام بذلك أثناء عملي	1/2/3/4/5/6/7
32.	أبدأ عملي حتى لو كانت بعض الموارد المطلوبة غير متوفرة	1/2/3/4/5/6/7
33.	أعتقد أن هناك دائماً إمكانية لتطوير وتحسين طريقة أدائي لعملي	1/2/3/4/5/6/7
34.	يطلعني "الفورمن" على جدول عملي الأسبوعي في بداية الأسبوع .	1/2/3/4/5/6/7
35.	أثناء العمل في نفس المكان, أعتقد أنه لا بأس اذا تواجدت فرق عمل مختلفة تقوم بمهام مختلفة وتستعمل مواد مختلفة	1/2/3/4/5/6/7
36.	أقوم بمراقبة ذاتية للأعمال الموكلة إلي من ناحية النوعية.	1/2/3/4/5/6/7
37.	أعتقد أنه يمكنني اختصار عدد الخطوات المطلوبة لإنجاز عملي	1/2/3/4/5/6/7
38.	يحرص كل شخص في الشركة على أهمية تطبيق قيم وأهداف الشركة	1/2/3/4/5/6/7
39.	أتلقى جميع المعلومات المتعلقة بعملي مثل طبيعة العمل ومكانه وزمانه والعمال الأخرون القائمون به	1/2/3/4/5/6/7

40.	لا بأس إذا انتظرنا وصول المواد إلى موقع البناء أو لنقلها لمكانها المناسب	1/2/3/4/5/6/7
41.	أعتقد أنه من المقبول جداً أن أتوقف عن القيام بمهمة معينة وأنتقل للقيام بمهمة ثانية ومن ثم أعود الى المهمة الأولى بعد مرور فترة من الوقت	1/2/3/4/5/6/7
42.	ان الوقت المطلوب لتنظيم مواد وأدوات البناء في صناديق أوحقائب أوأكياس هو وقت ضائع	1/2/3/4/5/6/7
43.	أمضي بعض الوقت كل يوم في البحث عن المواد أوالمعلومات أوالمعدات المطلوبة	1/2/3/4/5/6/7

شكراً

REFERENCES

Albert P.C. Chan, Ada P.L. Chan, (2004) "Key performance indicators for measuring construction success", Benchmarking: An International Journal, Vol. 11 Issue: 2, pp.203-221.

Ankomah, E. N., Ayarkwa, J., & Agyekum, K. (2017). A theoretical review of lean implementation within SMEs. ICIDA 2017 – 6th International Conference on Infrastructure Development in Africa, KNUST, Kumasi, Ghana.

Arbulu, R. J., Ballard, G., and Harper, N. (2003). Kanban in construction. Proc. 11th Ann. Conf. of the Intl. Group for Lean Constr. (IGLC-11), Elsinore, Denmark.

Barbosa, G., Andrade, F., Biotto, C., & Mota, B. (2013). Implementing lean construction effectively in a year in a construction project. In Proceedings for the 21st Annual Conference of the International Group for Lean Construction, Fortaleza, Brazil (pp. 1017-1026).

Beer, M., Eisenstat, R.A., and Spector, B. (1995). “Why change programs don’t produce change”. In: Kolb, D., Osland, J and Rubin, I. (1995). The organizational behavior reader. 6th ed., Prentice Hall, pp. 665-676.

Bernstein, H. M. & Jones, S. A. (2013). Lean construction: Leveraging collaboration and advanced practices to increase project efficiency. Intelligence, McGraw Hill Construction, Bedford, MA.

Brady, Denise Ann, Tzortzopoulos, Patricia and Rooke, John (2011). An examination of the barriers to last planner implementation. In: 19th Annual Conference for Lean Construction, 13-15th July 2011, Lima, Peru.Ballard, G., & Howell, G. (2004). An

Update on Last Planner. In Proceedings of the 11th Annual Conference of the International Group for Lean Construction, Virginia, USA.

Brunette, M. J. (2004). Construction safety research in the United States: Targeting the Hispanic workforce. Injury Prevention, 10, 244-248.

Burke, M J, Sarpy, S A, Smith-Crowe, K, Chan-Serafin, S, Salvador, R O and Islam, G (2006) Relative Effectiveness of Worker Safety and Health Training Methods "American Journal of Public Health", 96(2), 315-324.

Canales, A.R., Arbelaez, M., Vasquez, E., Aveiga,F., Strong, K., Walters, R., ... & Jahren, C. T. (2009). Exploring Training Needs and Development of Construction Language Courses for American Supervisors and Hispanic Craft Workers. Journal of construction engineering and management, 135(5), 387-396.

Chan, A. P., & Chan, A. P. (2004). Key performance indicators for measuring construction success. Benchmarking: an international journal, 11(2), 203-221.

Clarke, E. (2009). Learning outcomes from business simulation exercises: Challenges for the implementation of learning technologies. Education and Training, 51(5), 448–459.

Conte, A. S. I., & Gransberg, D. (2001). Lean construction: From theory to practice. AACE International Transactions, CS101.

Cooke, M., Irby, D. M., & Sullivan, W., et al. (2006). American medical education 100 years after the Flexner report. The New England Journal of Medicine, 355, 1339–1344.

Etges, B.M. , Saurin, T.A. & Bulhões, I.R. (2012). 'Identifying Lean Construction Categories of Practices in the IGLC Proceedings' In:, Tommelein, I.D. & Pasquire, C.L., 20th Annual Conference of the International Group for Lean Construction. San Diego, USA

Froyd, J. (2008). White paper on promising practices in undergraduate STEM education. Paper presented at the National Research Council's Workshop Linking Evidence to Promising Practices in STEM Undergraduate Education, Washington DC.

http://www.nationalacademies.
org/bose/Froyd_Promising_Practices_CommissionedPaper.pdf.

Garcia, S., Romero, A., and Diaz, H. (2006). “Incentive Plans for Mexican Construction Workers”, Proceedings of the 14th Annual Conference of the International Group for Lean Construction, IGLC 14, 2006, Santiago, Chile, pp. 525-532.

Gherardi, S and Nicolini, D (2002) "Learning the Trade: A Culture of Safety in Practice". London: Sage Publications.

Greenleaf, R. K. (2002). Servant leadership: A journey into the nature of legitimate power and greatness. Paulist Press.

Guerrero, S. and Sire, B. (2001) “Motivation to train from the workers’ perspective: example of French companies.” International Journal of Human Resource Management, 12 (6), 998-1004.

Hämäläinen, J. , Ballard, G. & Elfving, J. 2014, 'Are Tools and Training Enough - An Argument for Leadership', Proceedings of the 22nd Annual Conference of the International Group for Lean Construction. Oslo, Norway, pp 1357-1368.

Hamzeh, F. R. (2011). The lean journey: implementing the last planner system in construction. In Proceedings of the 19th Annual Conference of the International Group for Lean Construction, Lima, Peru, pp. 379-390.

Hamzeh, F. R. (2016). Using Forums and Simulation Exercises to Enhance Active Learning in Lean Construction Education. Ch. 6. In R. N. Nasser, & M. Romanowski, Social Justice and the Engineering Profession: Challenging Engineering Education to Move beyond the Technical (pp. 139-159). Springer, Cham.

Hamzeh, F.R. (2011), “The Lean Journey: Implementing the Last Planner ® System in Construction” In:, Rooke, J. & Dave, B., 19th Annual Conference of the International Group for Lean Construction. Lima, Peru,

Harrington, D., Materna, B., Vannoy, J., & Scholz, P. (2009). Conducting effective tailgate trainings. Health Promotion Practice, 10(3), 359-369. Doi: 10.1177/1524839907307885

James R. Wilkins (2011) Construction workers' perceptions of health and safety training programmes, Construction Management and Economics, 29:10, 1017-1026.

Koskela, L. (1992). Application of the new production philosophy to construction (No. 72). Stanford, CA: Stanford University.

Koskela, L. (2000), an exploration towards a Production Theory and Its Application to Construction, VTT Technical Research Center of Finland.

Koskela, L. (2004). Making do - the eighth category of waste. In Proceedings of the 12th annual conference of the International Group for Lean Construction.

Liker, J.K. (2004). The Toyota Way- 14 Management Principles from the World's Greatest Manufacturer. New York: McGraw Hill.

Liker, J.K. (2004). The Toyota Way- 14 Management Principles from the World's Greatest Manufacturer. New York: McGraw Hill.

Lorenzet, S. J., Salas, E., & Tannenbaum, S. I. (2005). To err is human: The impact of guided errors on learning, performance, and self-efficacy. Human Resource Development Quarterly, 16, 301–322.

Martin, B. O., Kolomitro, K., & Lam, T. C. (2014). Training methods: A review and analysis. Human Resource Development Review, 13(1), 11-35.

Mowlam, A, Mitchell, M, Jones, N, Ludford, H (2010) "How best to communicate health and safety messages to young learners in vocational education and training". London: HSE.

O'connor, T., Loomis, D., Runyan, C., dal Santo, J. A., & Schulman, M. (2005). Adequacy of health and safety training among young Latino construction workers. Journal of Occupational and Environmental Medicine, 47(3), 272-277.

Olivella, J., Cuatrecasas, L. and Gavilan, N. (2008), “Work organisation practices for lean production”, Journal of Manufacturing Technology Management, Vol. 19 No. 7, pp. 798-811.

Patton, J. R. (2013) Task Diminishment: Construction Value Loss due to Sub-optimal Task Execution. A Dissertation Presented to The College of Graduate and Professional Studies, Department of Technology, Indiana State University, in Partial Fulfillment of the Requirements for the Degree Doctor of Philosophy.

Ringen, K., Englund, A., & Seegal, J. (1995). Safety and health in the construction industry. Annual Review of Public Health, 16, 165-188.

Rother, M. (2009). Toyota kata. Managing People for Improvement, Adaptiveness and Superior Results. McGraw-Hill Professional.

Schuler, A.J. (2003). Overcoming resistance to change: Top ten reasons for change resistance, http://www.projectconnections.com/articles/020304-schuler.html

Slivon, C.A., Howell, G.A., Koskela, L. and Rooke, J. (2010). “Social Construction: Understanding Construction in a Human Context”, Proceedings of the 18th Annual Conference of the International Group for Lean Construction, IGLC 18, 12-16 July 2010, Haifa, Israel.

Stehn, Lars, et al. "Lean Principles in Industrialized Housing Production: The Need for a Cultural Change." Lean Construction Journal, 2008, pp. 20.

Tezel, A. (2011). Visual Management: an exploration of the concept of and its implementation in construction. Phd, University of Salford.

Viana, D.D., Mota, B., Formoso, C.T., Echeveste, M., Piexoto, M., and Rodrigues, C.L. (2010). “A Survey on the Last Planner System: Impacts and Difficulties for Implementation in Brazilian Companies”, Proceedings of the 18th Annual Conference of the International Group for Lean Construction, IGLC 18, July, Haifa, Israel, 497- 507.

Viana, D.D., Mota, B., Formoso, C.T., Echeveste, M., Piexoto, M., and Rodrigues, C.L. (2010). “A Survey on the Last Planner System: Impacts and Difficulties for Implementation in Brazilian Companies”, Proceedings of the 18th Annual Conference of the International Group for Lean Construction, IGLC 18, July, Haifa, Israel, 497- 507.

"When training works: strategies for effective learning", (2016) Development and Learning in Organizations: An International Journal, (30) (4), 21-23, https://doi.org/10.1108/DLO-03-2016-0029

Xavier Brioso, Teaching Lean Construction: Pontifical Catholic University of Peru Training Course in Lean Project & Construction Management, In Procedia Engineering, Volume 123, 2015, Pages 85-93, ISSN 1877-7058, https://doi.org/10.1016/j.proeng.2015.10.062.

Zanotti, N.L. et al. 2017, 'Bottom-up Strategy for Lean Construction on Site Implementation' In:, 25th Annual Conference of the International Group for Lean Construction. Heraklion, Greece, 9-12 Jul 2017. pp 325-331

Zoroja, J. (2010). Simulation games and their use in education at economics institutions in the Republic of Croatia. The Business Review, Cambridge, 15(1), 113–118.