Implementing Lean Construction using the Last Planner System in Northern Iraq

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Submitted to the
Institute of Graduate Studies and Research
in partial fulfillment of the requirements for the degree of

Master of Science
in
Civil Engineering

Eastern Mediterranean University
February 2016
Gazimağusa, North Cyprus

Approval of the Institute of Graduate Studies and Research

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ABSTRACT

With the continuous decline in profit margins and increased competition in construction projects, construction contractors are continuing to search for ways of eliminating waste and increasing profit. One important improvement initiative, with direct practical impacts, has been the adoption of Lean Construction (LC). The best known LC technique is the Last Planner System (LPS), which has been demonstrated as a very useful tool for the management of the construction process and the continuous monitoring of planning efficiency.

Nowadays, in Northern Iraq the increased economic growth as well as urbanization in developing cities has led into extensive construction activities that generate large amounts of wastes. Wastes in construction projects resulted into huge financial setbacks to builders and contractors. In addition to this, it may also cause significant effects over aesthetics, health, and the general environment. These wastes needs to be managed as well as their impacts needs to be ascertained to pave way for their proper management, however in many cities of Iraq waste management is still a problem.

The main objective of this study is to investigate the causes of waste in construction industry, at which level LC and LPS been implemented, and the effects of implementing LC using LPS in Northern Iraq. The research includes an extensive literature study, interviews with civil engineers, project managers, contractors, and a case study, analysis of this information to develop findings, and extending these to present the key issues that could be targeted for implementing LC using LPS. The

study will thus contribute to improving management practice and may aid the establishment of a basis for the development of further research in the area of LC. The research outcomes can inform practitioners of the opportunity to implement alternative management methods in construction, and give a good account of the opportunities and challenges. Beside the direct benefits to managerial practice, the study will also contribute to practice by offering practical recommendation that can assist in the achievement of the full potential of lean and LPS in Northern Iraq.

Keywords: Lean Construction, Last Planner System, Waste Management, North Iraq Construction Industry.

ÖZ

Kar marjlarındaki sürekli düşüş ve inşaat projelerinde artan rekabet ile, inşaat müteahhitleri israfları gidermenin ve karlarını artırmanın yollarını aramaya devam etmektedirler. Bir önemli gelişme, doğrudan pratik etkileri olan, Yalın İnşaat (Yİ) girişiminin benimsenmesi olmuştur. En iyi bilinen Yİ tekniği yapım sürecinin yönetimi ve planlama verimliliğinin sürekli olarak izlenmesi için çok yararlı bir araç olarak ortaya konan Son Planlayıcı Sistemi (SPS) 'dir.

Günümüzde, Kuzey Irak'ta artan ekonomik büyümenin yanı sıra gelişen şehirlerde kentleşmenin getirdiği kapsamlı inşaat faaliyetleri nedeniyle büyük miktarda israflar ortaya çıkmıştır. İnşaat projelerinde israflar inşaatçılar ve müteahhitler için büyük mali başarısızlıklarla sonuçlanmıştır. Buna ek olarak, aynı zamanda estetik, sağlık, ve genel çevre üzerinde önemli etkilere de neden olmaktadır. Bu israfların yönetilmesinin yanısıra onların etkilerinin uygun olarak tespit edilmesi için doğru yönetime ihtiyaç olmasına rağmen Irak'ın birçok şehrinde israf yönetimi hala bir sorundur.

Bu çalışmanın temel amacı Kuzey Irak'ta yapımdaki israfın nedenlerinin araştırılması, ve Yİ ve SPS uygulamalarının ve etkilerinin ne düzeyde olduğunun belirlenmesidir. Bu araştırma kapsamlı bir literatür çalışmasını, inşaat mühendisleri, proje yöneticileri ve müteahhitlerle yapılan mülakatları, vaka analizini ve bu bilgilerin analizi ile bulguların geliştirilerek SPS kullanımı ile Yİ uygulamasının hedeflenmesini sağlayacak önemli konuları içerir. Bu çalışma böylelikle yönetim pratiğini geliştirmeye katkıda bulunacak ve Yİ alanında ileriki araştırmalara bir temel

oluşturulmasında yardımcı olacaktır. Araştırma sonuçları yapımda alternatif yönetim yöntemlerini uygulama fırsatları için uygulayıcıları bilgilendirebilir ve firsatlar ve zorluklar için iyi bir hesap verebilir. Çalışma, yönetsel uygulamaya doğrudan faydalar yanında, aynı zamanda Kuzey Irak'ta tam yalın inşaat ve SPS uygulama potansiyelinin başarılmasında yardımcı olabilicek pratik öneriler sunarak katkıda bulunacaktır.

Anahtar Kelimeler: Yalın İnşaat, Son Planlayı Sistemi, İsraf Yönetimi, Kuzey Irak İnşaat Sektörü

To my beloved family

ACKNOWLEDGEMENT

The support and collaboration of numerous people, made this study to be impossible to whom I am obliged for their commitment. To start with, I am appreciative to the Almighty and Glorious God, for the every single interminable gift. Additionally I might want to say thanks to Assoc. Professor Dr. Ibrahim Yitmen for all his care and guidance on the way to the achievement of this exploration.

I might truly want to thank my friend and my sister Avesta, for demonstrating enthusiasm for my study and sharing profitable data. Additionally I might want to thank all the undertaking members who indicated extraordinary enthusiasm for Last Planner System. Without their bolster, investment, and recommendations this exploration would not have been completed.

To wrap things up, my sincere appreciation goes to my parents and my older brother Zana Othman for their love, support, and unwavering trust in my abilities. I am fortunate to have them in my life. My special thank is reserved for my beloved wife Hozan Ahmed who has established highest performance standards for me to work more diligently and follow her path.

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LIST OF ABBREVIATIONS

LC	Lean Construction
LPS	Last Planner System
LP	Last Planner
CM	Construction Management
NI	Northern Iraq
LT	Lean Thinking
IPD	Integrated Project Delivery
LP	Lean Production
MIT	International Motor Vehicle Program
TPS	Toyota Production System
LT	Lean Thinking
LPS	Lean Production System
LPDS	Lean Project Delivery System
PM	Project Manager
PMBOK	Project Management Body of Knowledge
CPM	Critical Path Method
PMI	Project Management Institute
IPD	Integrated Project Delivery
AIACC	American Institute of Architects California Council
ITQC	Institute for Technology and Quality in Construction
WWP	Weekly Work Plan
PPC	Percent Plan Complete
LAP	Look Ahead Planning

PPS	Phase Pull Schedule
6WLAP	Six Week Look-ahead Planning
3WLAP	Three Week Look-ahead Planning
GC	General Contractor
AEC	Architecture, Engineering, and Construction
BS	Baseline Schedule
CO	Change Order
CSFs	Critical Success Factors
EVM	Earned Value Method
JIT	Just-in-Time
LCI	Lean Construction Institute
PCT	Percent Complete
RFI	Request for Information
SCM	Supply Chain Management
TQM	Total Quality Management
MP	Master Plane
PPP	Phase Pull Planning

Chapter 1

INTRODUCTION

1.1 Background

The recent studies and surveys show that 30% of the construction costs are resulting from lack of efficiency, mistake, sustainability and absence of communication Forbes et al. (2004). The construction industry in the developed and developing countries confronts with such similar troubling obstacles. In these countries the concept of construction performance suffers from lack of concentration on the efficiency and initiative quality. The study of many researches brought out the industry tendency to qualify construction performance in terms of the following requirements: completion on time, completion within the funded budget, meeting the construction requirements and codes (Koskela, 2008). Indeed, very little attention devoted to the construction proprietor as a key performance measurement. Koskela (2008) advised that exclusively explanatory studies and novel management techniques could be progressed and practically implemented in the non-traditional research approaches such as construction and action research. This may help to address several of the persistent managerial troubles to raise performance and lead to much knowledge in the construction management (CM) field.

Construction is a series of actions intended to gain a certain output (Koskela, 1992). The process of construction is ordinarily broken down into main stages, for each the cost of materials, machinery equipment and workforce is estimated and time frame

for completing each stage. These stages assuredly consist of certain activities converting inputs into outputs and can be separately accomplished. In each stage of construction and design processes wastes directly or indirectly are produced. The reduction of waste within design is incredibly complicated since the amount of materials and number of planned activities could be very huge to the accomplishment of a single product such as an infrastructure project or a building (Koskela, 1992). Whereas, more waste creators added in various construction stages or through sub-contracting, process becomes more and more complicated (Keys, Baldwin, & Austin, 2000). Lack of a theoretical and conceptual framework in construction still exists in spite of these shortages of the activity models. The focus on activities conceals the waste generated in the ongoing activities through unpredicted resource delivery or release of work. In other words such current events and production forms make these activities be taken into account and disregard shortcomings and value considerations (Koskela, 1992).

Construction waste is arranged based on type, quantity, etc. Despite of dissimilar arrangements, most of them follow the same principle idea. Shingo (1984) separated construction waste into seven kinds based on their reasons. These reasons are the organization itself, stock, operation, transportation, waiting period, overproduction, and defect. In another study, Koskela (1992) counted deficiency, revise, project error, oversight, replace sequence, safety, cost and over consumption of materials as waste collections that arisen in construction procedures.

The gradual growth of international cooperation and absence of experts or experienced efforts, require urgent demand to increase the excellence of standards,

creativeness and the implementation of fresh skill to the construction projection (Koskela, 1992).

The wastes are affected by many restraints of the design process; such as the complexity of design, selection of the materials, coordination and communications within different disciplines (Keys, Baldwin, & Austin, 2000).

The earlier published researches mainly aimed at accelerating the implementation construction process and improving the overall productivity with the introduction of new technologies, and equipment keeping the common project management techniques. The focus mainly was on time-cost- quality tradeoff. However, LC as a new form of project management reinforced by powerful capabilities through application of BIM expected to provide variety of procedures and results expected to the achievement of efficiency in resources and more sustainable buildings.

LC maximizes value and reduces waste. It accomplishes these objectives through the use of Supply Chain Management (SCM), Just-In-Time (JIT) techniques as well as sharing information to all the concerned and involved parties of the production process. Lean concept that developed by Taichii Ohno in the 1950s, based on lean manufacturing. The lean philosophy includes minimizing waste in all forms and continuous improvement of processes and systems.

Ballard and Howell (2003) planned the LPS as one of the methods for applying lean techniques to construction. It provides productive unit and workflow controls and alleviates swift responses to correct for deviations from expected outcomes through

using root cause analysis. Control is defined as “causing events to conform to plan,” as opposed to the construction tradition of monitoring progress against schedule and budget projections. LPS focuses on the reduction of workflow hesitation. It was established to help the project planner in decreasing the doubt inherent in the preparation procedure. LPS uses a systematic process to produce reliable work plans targeted at protecting the downstream work procedures from upstream indecision by means of planning and corresponding the workload to obtainable resources. “The person accountable for creating the latest level of plans in the planning hierarchy” Kartam et al. (1995a & 1995b).

Architecture, Engineering, and Construction (AEC) procedures are essentially changeable and indeterminate. The LPS has been effectively executed in manufacture schemes to expand the dependability of planning, manufacture process, and improving the workflow in project and construction processes (Ballard & Howell, 2004). The LPS suggests a methodical procedure for construction planning, assumed the administrations complicated have comprised a “lean philosophy”.

1.2 Problem Statement

One important improvement initiative, with direct practical impacts, has been the adoption of LC. Since the early 1990s, LC has evolved as a new way to manage construction more efficiently and effectively. Diverse lean techniques have been adopted in practice, aiming to enhance project management by eliminating waste, improving planning efficiency and reliability, improving productivity and maximizing value.

The best known lean construction technique is the LPS, which has been demonstrated as a very useful tool for the management of the construction process and the continuous monitoring of planning efficiency. LPS has been tested in the field and refined over the last decade, with many reported benefits in diverse environments around the world. Now days, in Iraq the increased economic growth as well as urbanization in developing countries have led into extensive construction activities that generate large amounts of wastes. Material wastage in construction projects resulted into huge financial setbacks to builders and contractors. In addition to this, it may also cause significant effects over aesthetics, health, and the general environment. These wastes needs to be managed as well as their impacts needs to be ascertained to pave way for their proper management, however in many cities of Iraq wastes materials management is still a problem.

1.3 The scope and objectives of the study

The main objective of this study is to investigate the causes of waste in construction industry, at which level LC and LPS been implemented, and the effects of implementing LC using LPS in Northern Iraq. The research includes an extensive literature study, interviews with civil engineers, project managers, contractors, and a case study, analysis of this information to develop findings, and extending these to present the key issues that could be targeted for implementing LC using LPS. The study will thus contribute to improving management practice and may aid the establishment of a basis for the development of further research in the area of LC. The research outcomes can inform practitioners of the opportunity to implement alternative management methods in construction, and give a good account of the opportunities and challenges. Beside the direct benefits to managerial practice, the study will also contribute to practice by offering practical recommendation that can

assist in the achievement of the full potential of lean and LPS in Northern Iraq.

The questions raised in this research are as follows:

1. What are the causes of Waste in construction industry of NI?
2. At which level has LC and LPS implemented in NI?
3. What will be the effects of implementing LC in NI?

1.4 Methodology

This study was executed in five major stages.

1. **Literature survey;** intensive study of the earlier works in the area of LC that assisted the researcher in developing implementation strategy.
2. **Research Design;** this stage concentrates on initial framework development for implementing LPS in Construction Industry.
3. **Data Collection;** methods for data collection including interviews, questionnaires, case study and documentary analysis.
4. **Data Analysis and Evaluation;** a simply meaningful analysis of measured data and evaluation of LPS implementation executed objectives of this thesis.
5. **Final Report**; an overview of the outcomes of the research have been recorded and documented in this thesis.

1.5 Expected Consequences

The following outcomes are expected in this study:

1. The advantages of LPS will be presented through the improved performance of the project planning process at every phase.
2. The related industries will be furnished with the studies demonstrating possible obstacles and associating issues of the implementation of LPS at a construction project.
3. Recommendations and suggested ideas will be processed to overcome such

possible difficulties for more effective implementation of LPS.

1.6 Structure of Thesis

Chapter one presents introduction, problem statement, methodology and the probable outcomes of this research. Chapter two provides a literature review on the LPS and tools for executing LPS. Chapter three illustrates LPS implementation strategies in detail through step by step and how to collect data from the construction industry and case study. Chapter four outlines the results and consequences of the research and implementing this tool in the case study. Chapter five draws conclusions and offers recommendations for further studies. References and appendixes are provided at the end of this research.

Chapter 2

THE LITERATURE REVIEW

2.1 Introduction

This chapter will examine the Implementation of LC using the LPS in different reigns of the world based on previous researches and existing literature. Firstly, the key principles of lean construction will be explained. Secondly, the lean philosophy of project planning will be discussed. Then, the chapter illustrates some scholars' views about LPS. Finally, LPS essentials will be presented.

2.2 History of LC

2.2.1 History of Lean Production

According to Womack, Jones and Roos (1990), the term “Lean Production” was first introduced by John Krafcik of MIT International Motor Vehicle Program as a new production methodology in which fever resources, manpower, manufacturing space, engineering hours, tools and inventory warehouses are used in comparing to mass production. Following Henry Ford’s flow-based production management, which covers advantages of both mass production and craft production, Japanese Toyota’s Engineers Ohna and Shingo have developed The Toyota Production System (TPS). The main goals of TPS were customer satisfaction, zero waste, minimizing the inventory and product perfection.

Lean thinking is focusing on the value of the product more than the administration process (Howell, 1999).Lean thinking considers the entire project as one large

operation, on the other hand the current project management methodologies which consider the projects as combination of activities.

The Lean production model focuses on the final value produced to the customer, since the total cost and duration of the whole project are more significant than the cost or duration of any single activity. Commonly, organization is talented by central schedule while the work flow facts are achieved through the association by people who are alert of and funding project goals (Howell, 1999). Value, material and the program of information and materials to achievement are the key purposes of Lean production theory.

In a production system, waste can be defined according to the performance criteria. If the client's specific requirements are failed to be met, this is considered to be waste. Waste can be diminishing by reducing the differences between the current situation and the perfection (Howell, 1999).

2.2.2 Lean Construction (LC)

The term "Lean Construction" was devised by Glen Ballard and Gregory Howell in 1990s of through implementation of Ohno's production system design criteria as a standard of precision. Unlike the industrial where unalike parts are complete to collect the final invention, designing and constructing a single project in highly inexact situation under the compression of time and calendar is totally dissimilar. Transformation of the Lean Production System (LPS) from concepts, into practice has been initiated by many researchers (Womack & Jones, 1996).

LC is a project delivery system based on the perception of production management

warranting the reliability and speed of value delivery. In general, work on Lean Construction is direct via two core concepts; Koskela's Transformation-Flow-Value and Last Planner methods of production control by Ballard and Howell.

According to Koskela (2000), LC is based on two production theories: flow and value. First, the flow concept emphasizes on the waste reduction. Second is the value generation concept takes the value delivered to the customer into consideration. The LC practices and methods based on both of these concepts are significantly diverse from those based on the traditional transformation concept of production which perceives production as transformation of inputs into outputs (Koskela L., 2000).

2.2.3 Lean Project Delivery System (LPDS)

Lean Project Delivery System (LPDS) is a construction management methodology inspired by Toyota Production System (TPS), focuses on producing value without generating waste. LPDS's next level is collaboration among the staff by founding a team in which the architects, builder and all other critical employees and labors are treated as one equal group to meet client goals (Jr. And Michel, 2009).

Figure 2.1 introduces LPDS schema as a series of phases represented as overlapped triangles. The first phase is "Project Definition" in which customer's purpose, design concepts and customer's constrains is represented. Because these features might affect each other, this leads to the necessity of contact and dialog between stock-holders, and this expands their vision and understanding. (Ballard & Howell, 2003; Ballard, 2008)

It is vital for the LPDS' project delivery team to provide the customer with various

ideas and help the clients to decide what they require, then afford their needs. Once the customers' purpose and constrains are recognized, it will be easier to introduce alternative ways for accomplishing the required project apart from those methods that have previously considered. Moreover, this process also helps clienteles to comprehend the penalties of their needs.

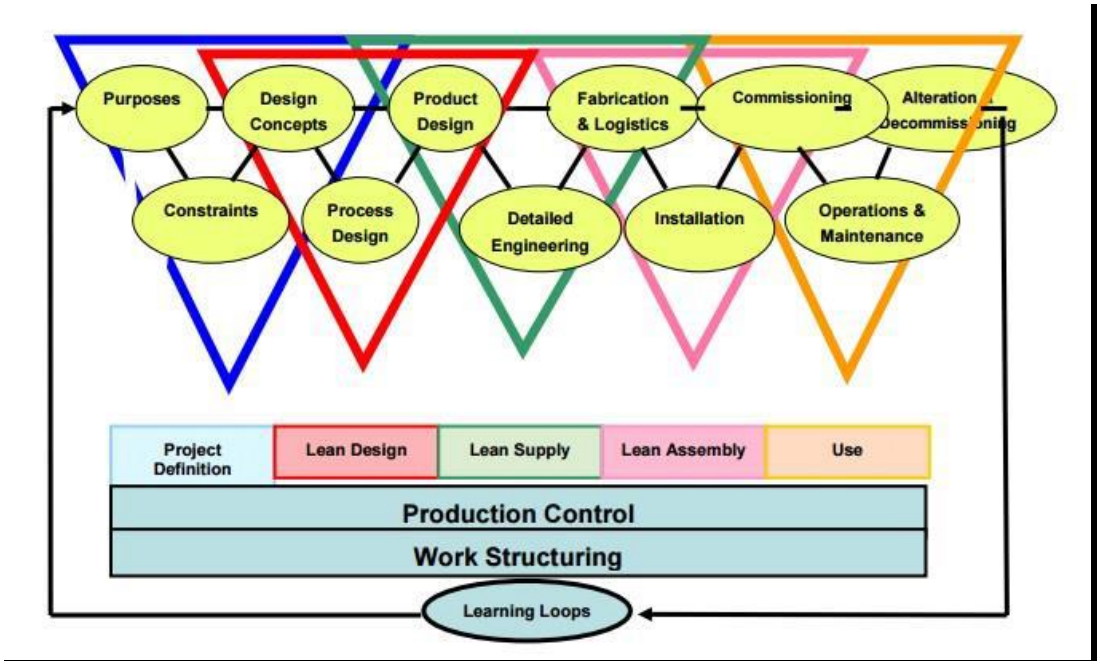


Figure 2.1: Lean Project Delivery System

2.2.4 Fundamental Lean Principals

In the light of Lauri Koskela's work; the following list of principles are thought to be important to Lean production (Diekmann, Krewedl, Balonick, Stewart, & Won, 2004):

2.2.4.1 Meeting Customer's Requirements

The product quality which is required by the customer should be taken into consideration. The production success depends on the customer satisfaction. As a practical approach, the customer requirements should be determined and analyzed in each production stage.

2.2.4.2 Reducing Non-Value Adding Activities.

Three fundamental drivers of non-worth included exercises are generally known:

1. Production framework structure, which recommends that the regulation of physical stream can be restricted through information and material.
2. Production framework controlling means.
3. Production framework nature, for example, machine disappointments, fortuitous events or blames or deserts.

2.2.4.3 Reducing Cycle Time

Process duration is the whole time required to finish a venture.

It can be arranged as:

1. Process duration = Processing time + checkup time + Waiting time + Moving time The accompanying exercises have been distinguished to lessen process duration:
2. Removing work in advancement (WIP).
3. Reducing the group size.
4. Changing the undertaking diagram to diminish the moving space.
5. Making the stuffs movement, smooth and synchronize.
6. Diminish changeability.
7. Untying the main value adding order from support activities.
8. Assembling the activities to flow in parallel order instead of consecutive order to save time and budget.

2.2.4.4 Reducing Variability

It is believed that Variability increases cycle time; variability of activity period supplements is including exercises. Here is some recommended variability lessening methodologies:

1. Activity regulation, this can be performed through executing standard methods.
2. Mistake-sealing techniques.

2.2.4.5 Increasing flexibility

It is crucial to expand the creation line ability to take care of the business sector demand and alterations Stalk (1990), prescribes the accompanying exercises to build the yield adaptability:

1. Minimizing the parcel size however much as could reasonably be expected to coordinate the interest.
2. Reducing the operation and changeover inconveniences.
3. Modifying as late in the advancement as potential.
4. Providing Multi-gifted workforce preparing.

2.2.4.6 Increasing Transparency

To solve the detected mistakes fast and easily, it is crucial the entire flow operation to be observable and clear for all those who involved in the project.

2.2.4.7 Maintaining Continuous Improvement

The operation and the project's management techniques should be improved incessantly. These are some approaches which are considered to be critical for continuous improvement:

1. Progression assessing and monitoring.
2. Expanding the target's setting in order to the problems and solves them.
3. Bountiful all staffs the development duty; fixed development should be essential and satisfied from every separation within the association.
4. Applying standard methods as best practice plans in order to challenge continuous improvement with better techniques.

5. Connecting improvement to control, improvement should eliminate the present control restrictions and problems from the root rather than reducing their influence.

2.2.4.8 Disentangling by Reducing Numeral of Stages, Portions and Connections

Difficulty causes waste and supplementary expenses. The process should be restructured through fusing activities, using standard tools and materials in addition to reducing the amount of required control information.

The following methods are considered to be practical approaches to simplifications:

1. Flows limitation through combining activities.
2. Changing the design to reduce the parts of the product.
3. Systematizing tools, material and other parts.
4. Spiriting linkages.
5. Minimizing there required.

2.2.4.9 Fixating Switch on the Comprehensive Procedure

For maximum movement control the focus must be on the entire process, and section flow can be avoided since it causes to sub-optimization.

2.2.4.10 Adjusting Flow Improvement with Conversion Improvement

1. In order to create a balance with in the process both flow improvement.
2. And conversion improvement s should be analyzed individually. Never the less they are interrelated.

2.2.4.11 Benchmarking

Benchmarking supports break though the improvement of the process through some fundamental recon figuration.

2.2.4.12 Lean Construction Tools and Methods

The tools and methods applied to accomplish Lean Construction have been studied by Salem et al. (2006) and Minkarah (2006) as shown in Table 2.1.

Table 2.1: Summary of the tools and techniques in Lean Construction

Scope	Technique	Requirements	Criteria/change	
Flow variability	Last planner	Reverse phase	Pull approach	
				↑
		Scheduling	Quality	↑
		Six-week look-	Knowledge	↑
		ahead		
		Weekly work plan	Communication	↑
		Reasons for	Relation with other	↑
		variance	tools	
		PPC Charts		↑
Process variability	Fail safe for	Check for quality	Actions on the job	↑
	quality		site	
		Check for safety	Team effort	↑
			Knowledge	↑
			Communication	↑
			Relation with other	↑
			tools	

Transparency	Five S's	Sort	Action on the job site	↑
		Straighten	Team effort	↑
		Standardize	Knowledge	↑
		Shine	Communication	↑
		Sustain	Relation with other	↑
			tools	
	Increased	Commitment charts	Visualization	↑
	visualization	Safety signs	Team effort	
		Mobile signs	Knowledge	↑
		Project milestones	Communication	↑
		PPC charts	Relation with other	↑
			tools	
	Huddle meetings	All foreman	Time spent	
Continuous				
improvement		meeting		
		Start of the day	Review work to be	↓
		meeting	done	
			Issues covered	↑

2.2.5 Lean and Traditional Construction Management differences

LC philosophy is considerably distinct from the traditional PM practices which are built on the PM Body of Knowledge (PMBOK) founded by the Project Management Institute (PMI), according to (Forbes & Ahmed, 2011) these differences can be recapitulated as bellow:

1. Utilizing improved transient arranges and controller.
2. LC not able to substitute the customary calendar characterizing apparatuses, for example, Critical Path Method (CPM). LC works inside customary administration hone and enhances the conveyance of short

term.

3. LC believes that planning effectiveness should be restricted because of the unplanned actions, which sometimes occur. Implementation of arranged methods, embracing scheduling techniques, centering the short term plans for instance, The LP is considered more effective.
4. The LC's concern is the value, while traditional PM's philosophy is to focus on the schedule, and cost control.
5. Knowledge and flexibility enable LC to contract with indecision and accidental activities especially in compound schemes, whereas CPM is an estimation of completed also it is less real in managing the particulars of the way that the work should be done.
6. In General, PMBOK works well with rather simple and expectable projects; on the other hand LC is considered to be more effective.

2.2.6 Utilizations of Lean Ideas in Manufacture Industry

In an attempt to overcome the problem of accumulation of WIP, lean concepts might be executed through on-site process visualization. This can be performed through using status board generator software by drawing small icons that each one indicates the work state as well as the future tasks. The status board helps the work supervisor to assign the team effectively according to the nature of the work, which task needs to be done first and which one requires to be ready on.

Furthermore, the status board is beneficial in progress monitoring and making the project tutus data and information clear and available in all management stages. Consequently computer aided visualization tools improve the workflow through revealing the progress amount and the obstacles of the process Sacks, Treckmann, &

Rozenfeld, (2009).

2.2.6.1 Improving Labor Workflow in Construction

The influence of work flow as a lean principle on the labor work flow has been the core of several studies. In 2003, a study involved 3 bridges construction in 137 working days, the flexible capacity method was chosen as a possible concluded that incompetent labor flow results in ineffectual flow management (Thomas and et al, 2003).

Randolph et.al (2002) used data from 14 concrete framework project to conduct a study to explore the issue of construction variability and its influence on project performance; they found that decreasing the variability in labor productivity is more correlated to better performance than declining variability.

2.2.6.2 Formwork Engineering

These enhancements are due to the fact that LC decreases the wastes caused by walking and looking for mold assembly and machining.

2.2.3.3 Construction Projects

The aftereffects of actualizing LC strategies in a venture of building 80 lodging units in Nigeria, demonstrated that time administration improvements lead to sparing spending plan, following the undertaking was finished in 62 days rather than 90 days (Adamu and Hamid, 2012).

2.2.6.4 Precast Concrete Fabrication

Executing incline ideas in development of precast cement lessen process duration, and enhance the efficiency (Ballard, Harper, and Zabelle, 2003).

2.2.6.5 Infrastructure Projects

Lean techniques implemented in a study about tunneling project. The research's

results were increasing of the productivity by 43%, the project completed on time, and the profits were doubled (Wodalski, and et al, 2011).

2.3 Wastes in Construction

2.3.1 What is Waste?

Waste is the unnecessary use of time, materials and energy. Koskela (1992) defines waste as using more than the required amount of tools, materials and abilities in production of a building waste often adds extra expense without increasing the value of the final version of the product.

Tommelein(2015:) supports Koskela's claim and states that:

''In short, waste is anything the customer is not happy to pay for"

However waste in construction contains many things, the majority of the studies have focused only on the waste of materials. This is considered as one of the reasons that affects the construction process and results in wasting many other things. One of researches about material waste measurement is the study which – conducted by Agopyan et.al. Formoso et al. (1999) summarized the main points as;

1. Some firms have ignored about the waste in materials, as they do not apply a clear material management procedures to avoid waste in sites to control the material usage.
2. Most of building companies are not aware about the waste amount, and how to avoid it.
3. The main reason of waste in building construction relates poor planning to the beginning such as, insufficient design, and deficiency.

2.3.2 Classifications of Wastes

The extent of unavoidable waste is various depending on the project's location, organization and on the implemented technology.

Waste can likewise be considered by birthplaces, i.e. the stage in the system associated with the main driver of waste. Normally waste is distinguished inside of the generation stage; however there is the likelihood of having waste in prior stages, for example, arranging, plan, supply, and preparing of labor.

By (1989), proposes that Waste can be ordered into seven sorts as indicated by its temperament, the eighth waste sort is, – underutilized laborers' gifts - was presented by Bodek (2007).

2.3.3 Underutilized People

It is essential to employee skilled people, but as Garret and Lee (2010) state inefficient use of these people's mental and physical capabilities results in waste.

2.4 Lean Philosophy of Project Planning

Ballard (1994) states that planning more efficiently is one of the effective ways to increase productivity, though reducing delays ,completing the job in the best constructability order, connecting labors to available work, and organizing multiple reliant activities, etc. . Planning and control are considered to be interrelated and complementary processes in LC maintained during the project.

Planning constructs the strategies required to get to the project objectives. At the same time, control pursuits that each event occurs according to the planned sequence, in order to re-plan when the previously established arrangements are no longer appropriate or convenient. When events go in a wrong direction, feedback will be

help full to get experience and making better plans in the future (Ballard 2000; Howell 1999). Howell (1999) claims that control has been redefined from "monitoring results" to "making things happen." A planning system's performance is developed to promise dependable workflow and expectable project results. In Lean Construction, planning and control are the two sides of a coin that spin during a project:

- Planning: refers to standards for accomplishment and plan making for reaching objectives.
- Control: Causes actions to be accordance with the strategy and endorsing experience and re-planning.

Ballard (1994) believes that improved preparation is the result of overcoming common obstacles in the construction manufacturing, including:

1. Organization focuses on controller, which avoids evil deviations; and neglects innovation, which causes decent deviations.
2. Planning is considered to be the aids and aptitudes of the people who are responsible of planning rather than to be a system.
3. Planning consists of scheduling, in the first place while crew level planning takes the secondary concern.
4. Planning scheme presentation is insignificant.
5. Analyzing arrangement letdowns and solving the problems from the root is neglected.

The LPS which is known as one of the best techniques which has been confirmed to be a beneficial tool for the construction process management, and continuous

observing of the planning effectiveness.

The LP includes; master plan, level planning, look-ahead planning, weekly work planning (WWP), Percent Planned Complete (PPC) and reasons behind incompletion, Systematically implemented last planes brings several advantages and adds benefits to overall construction management and planning practice in particular.

2.5 Key Principles of LC

According to Womack and Jones (1996) following five key principles are vital for any LC system.

1. Value: The customer's requirements should be clarify in order to indicate activities or products that improve the value.
2. Value Stream: The construction process can be developed through planning the entire value stream, forming collaboration among participants, recognizing and reducing waste.
3. Flow: Business flow contains project data (specifications, agreements, strategies, etc.). Job site flow includes the activities and the way that these activities should be managed.
4. Supply flow: refers to all the constituents which are used in a project.
5. Pull: The participants' efforts stabilize pulls throughout the construction procedure.
6. Perfection: Includes work guidelines, procedures and quality controls.

2.6 Last Planner System (LPS)

Ballard (2000) and Howell (1999) developed the LPS as a construction planning and control system in order to reduce variations in construction work flow, improving future planning, and eliminating construction operation uncertainty.

At the beginning the system experienced variations in workflow at the WWP stage, and then it was prolonged to shelter the whole planning and schedule improvement process from master planning to phase planning through Look-ahead Planning (LAP) and WWP.

As a lean tool, LPS suggests:

1. Planning in more detail as it is time to perform the work,
2. Improving the work plan through consultation with the project performance team.
3. Team working, to remove work constrains, complete the work and increase, and work plans' reliability.
4. Making reliable promises completing the work based on collaboration and negotiation with the project contributors.
5. Catting experience from planning failures, solving the problems' root causes and preventing their repetition (Ballard, 2000; Ballard et al., 2007).

Figure 2.2 shows the LPS planning processes with different sequential spans: master scheduling, phase scheduling, look-ahead planning, and weekly work planning.

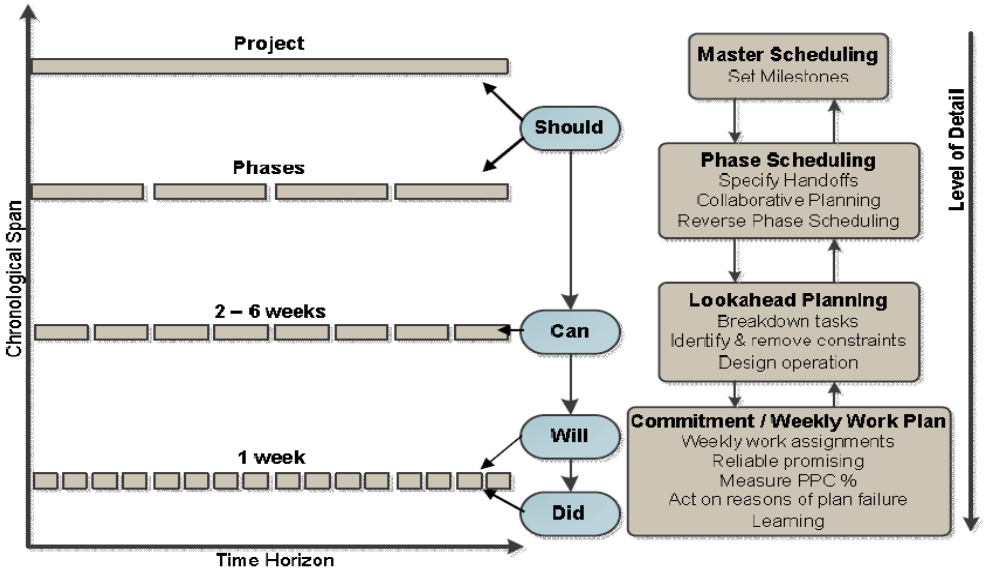


Figure 2.2: Planning Stages / Levels in the LPS

The master schedule is the product of front-end planning describes the works that should be carried out over the duration of a project

Commitment planning refers to the most thorough plan in the system representing interdependence among the various work specialist organizations. It directly governs the production produce. When each plan period finished, the work is reviewed to measure the reliability of the planning and the construction system. Examining the reasons of plan failures and solving the problems are significant for continuous improvement Ballard, (2000).

2.7 Should-Can-Will-Did Analysis

Decisions regarding concerning the work order according to the time and used resources and methods are made at every phase of the process, and occur throughout the project, which eventually leads the designers to produce assignments that direct physical production. The “last planner” is the last in the process because the production of planning process is not directed for a lower level planning procedure,

and the production results are shown in Figure 2.3 (Ballard and Howell, 1998).

Stabilizing the work environment though imitates learning to make and maintain commitments. Last planners can be predicted to make commitments (WILL) to doing what (SHOULD) be done, only to the point that it (CAN) be done. Demonstrating this as a rule might be: Selecting assignments from feasible accumulation; i.e. from activities that can be done.

LP provides the field only with only workable jobs, the traditional practice (Figure 2.4) pushes assignments on construction team and design body in order to complete the job on scheduled dates. In addition to looking ahead and indicating future tasks for constraints, assignments are also anticipated to encounter the exact feature requirements for definition, order and size. Furthermore, mistakes still occur, for this purpose the control system is designed in a way that promotes learning from plan failures, and avoiding repeating the same mistakes.

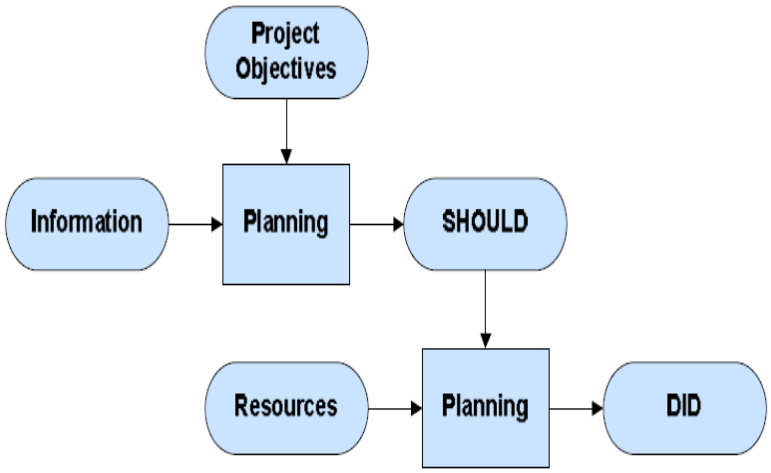


Figure 2.3: Traditional Planning Process (Adapted from Ballad and Howell 1998)

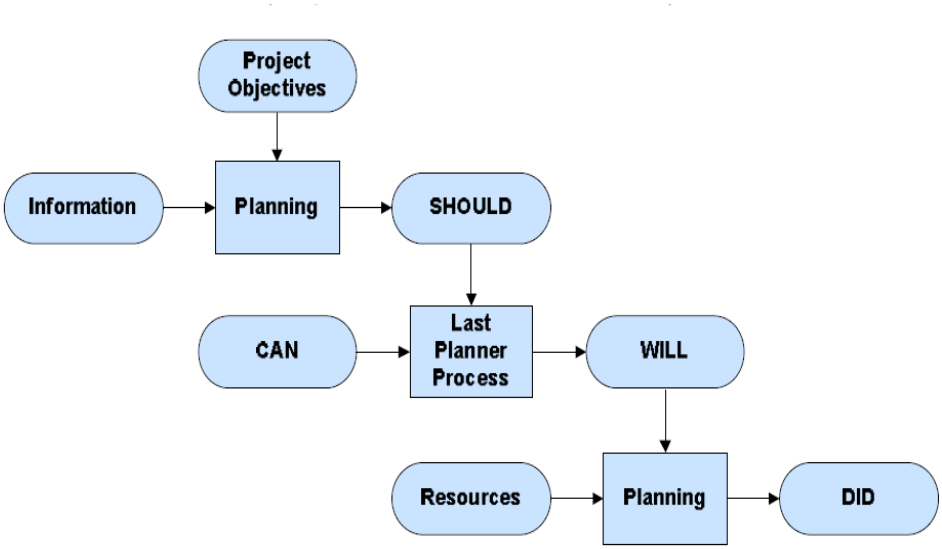


Figure 2.4: Last Planner Planning Process (Adapted from Ballad and Howell 1998)

Making quality assignments avoid production units' work flow uncertainty, enabling the units to increase their own productivity and the productivity of the downstream production units that build on their work and they are reliant on reliable work requirements or resources shared resources to their organize thesis (Ballard and Howell 1998).

2.8 LPS Essentials

The LPS essentials can be categorized to:

2.8.1 Milestone Schedule

The milestone schedule expected to divide the project into logical stages. The duration should be appropriate for those who are in charge of the project in order to complete the planned work confidently. Establishing convenient duration possibly requires improvement of a more thorough CPM, and negotiation and investigation with the project's producers, designers and constructions.

2.8.2 Pull Schedule (Baseline Schedule)

1. It is all the team members' responsibility to complete the work which is the milestone in improving the Phase Pull Schedule (PPS).
2. Face to face discussion develops PPS which establishes context, delineates the milestone deliverable, improves an implemented strategy, classifies tasks and arranges them in a pull plan working from the end of the phase back.
3. All chores on the PPS should produce a deliverable defined which suits and accepted by the customer.
4. PPS completes when the team members approve the hand-off criteria between activities, order and timing of the work. The team members feel confident because they have access to sufficient resources and time accomplish the activity also have identified long lead supplies.

2.8.3 Look-ahead Plan (LAP)

1. Activities in the PPS well-known tasks in the 6 Week Look-ahead Plan (6WLAP) each week.
2. Keeping the record of the linkage concerning tasks in the LAP and PPS activities.

3. Sub-tasks can be formed and connected to tasks in the LAP. The hand-off of work between trades is usually established in PPS level tasks. Sub-tasks are typically accomplished within each task.
4. Tasks and sub-tasks are deliverables.

2.8.4 Identifying Constraints

1. Constraints are the directives, resources and required work which are required to begin and complete the tasks but not shown on the PPS.
2. The connection between constraints and tasks will be sustained.
3. Tasks (and sub-tasks) on LAP are screened for constructions by the responsible people and at least when assigned to LP.
4. That who are in charge of the tasks removes those constraints within their authority or ask for help from shoes who beyond their authority.
5. The constraint log present the task's condition in workflow loop in terms of – declined, approved, in negotiation, guaranteed, in progress, or completed.
6. The LAP (and possibly the PPS) is various in responding to constraints that are irremovable by the time required.

2.8.5 Preparing Weekly Work Plan (WWP)

1. The tasks in the WWP should be in the 6WLAP and connected to PPS.
2. WWP should include only tasks that are ready to be executed, which means that all their constraints have been removed. The LP is assured that any remained tasks, the site and the staff will be available whenever required.
3. Occasionally, tasks which are not in a ready condition may include in WWP even though the LP is unconfident that they can be completed. In this case, it is required to notify to next LP that the mission might not be delivered.
4. Assignments on the WWP are sized for daily accomplishment. Larger

assignments could be made however this is impractical, because the work spans several days and it is difficult to establish.

5. The tasks should be inspected in WWP before the crew starts their job.

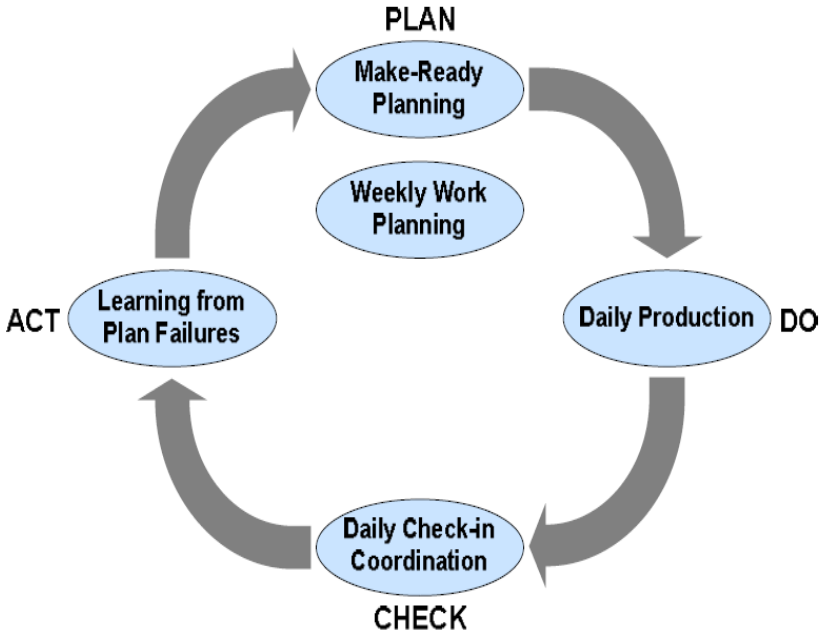


Figure 2.5: Weekly Planning and Execution Cycle

2.9 Chapter Summary

In this chapter based on comprehensive literature and scholars view the general sense of the concept of LC and its key principles, lean philosophy of project planning, LPS and its essentials in adding to should-can-will-did analysis have been presented.

Moreover, the levels of LPS were briefly discussed and additionally, a clear comparison between the traditional planning process and LP process were established.

Chapter 3

RESEARCH METHODOLOGY

3.1 Introduction

This chapter illustrates the empirical research and explains the utilized practice in this study such as, questionnaire, interviews, and case study, the advantages and details indicating these methods. Furthermore it demonstrates the research questions and their assumptions, the applicants of the study, the statistics and data collection method and analyses.

3.2 Research Questions

Through a survey conducted among Kurdish engineers, contractors and subcontractors following a case study conducted by the researcher, this research intended to find what are their viewpoints about LC using LPS in Northern Iraq (NI) construction industry. Based on the literature review presented in earlier chapters and researches some questions were outlined to comprehend the participants' opinions. These responses will be evaluated and analyzed under the theoretical studies guidance in Chapter two.

In this section the demands are categorized into three dissimilar groups:

3.2.1 What are the Causes of Waste in Construction Industry?

This question deals with waste factors.

- Which factors affect waste?

- What should be done to reduce waste?

It is expected that the gap between two activities, unnecessary movement of materials and workers, lack or inefficiency of the equipment, unskilled employees, poor management and lack of communication among the staff and other people who are connected with the project are amongst the fundamental factors that may cause waste.

Moreover, it is predicted that Government, new project management, tools such as LPS, increasing the awareness, and discussing the ideas with the employees can support actions and contribute in reducing waste.

3.2.2 At which level has LC and LPS implemented in NI?

This question deals with the existence of LC in construction industry in NI:

- Are there many factors that cause waste in construction, and is it necessary to take an action to improve construction industry in the NI through using up-to-date methods?
- What is the benefit of WWP and PPC in construction industry?

Depending on the viewpoint that NI is one of the third world countries, there might be a very little information about LC. It is expected that LC has not been implemented in NI, and due to this there are many factors that contribute in increasing waste. Also it is expected that contractors, engineers and sub-contractors imply different ways to reduce waste rather than implying LC using LPS.

3.2.3 Is it appropriate to implement LC in NI in the future?

Concerning to this demand, the participants are inquired to response more precisely the following questions:

- What is the CSF for implementing LC in NI?
- What are the main difficulties faced by the companies during the implementation? And what are the factors that promote the implementation of LPS.

Depending on the participants' experience, this question intended to find out to what extent they desire this method to be implemented in construction industry in NI in the future. However, it is expected that the participants may have very limited information about LC and LPS but they might like the idea and the approaches to be executed in the future.

Additionally, since NI is trying to develop, executing new methods is one of the indispensable steps to take. For this reason, evaluating experienced people's involvements, assessing the problems faced by the companies, and taking the participants’ views about Critical Success Factors into consideration are crucial as well.

3.3 Participants

The participants of this survey like Sekaran introduces them 'population' are Kurdish contractors and engineers that the presently working on construction projects in both public and private sectors.

The main cause behind choosing these people is that they have knowledge about the construction industry and they might have enough information which enriches the study.

3.4 Sample Size

Indicating an appropriate sample size to be investigated is one of the most difficult parts of the studies because it requires cautious consideration. The sample size should be chosen wisely since a small model cannot represent a dependable data at the same time large sample size consumes both the researcher and the participants' resources and time. The scholars claim that the sample size determination might be influenced by:

- The extent of the participants' wish to take a part in the research.
- The extent of data risking because of some factors, such as, confidence.
- The available resources for the researcher. for instance, the essential technology, time, and size of participants.

Also Dornyei (2002) asserts that, a proper data and results are the result of a proper sample size nevertheless often it might require more time and effort.

60 male and female participants received the questionnaire. Some of the participants were handed the questionnaires directly whereas the others due to the distance, received it through email. 52 of them completed the questionnaire and returned it on time. Then, four of them participated in the interviews and the fifth one was a group interview. Furthermore, one case study has been included. The reason for choosing this sample size was, this number is handy to manage, most people are busy and they might unavailable or uncooperative and there was not any available data about how

many construction companies or engineers are in NI. Also due to the countryside of the content and the investigation topic, Google form was used and certain people were chosen to participate instead of using new technology such as 'Survey monkey' to make sure only those who are connected with construction industry complete the questionnaire.

3.5 Research Tool

Both qualitative and quantitative methods have been used. Based on McDonough and McDonough (1997) researches, questionnaire, interviews and case study were the key tools that have been used in this investigation. All the data was collected from the applicants' knowledge throughout working in construction sites in the NI.
A 'mixed method' as Lund (2012) calls it, has been chosen because none of them is superior to the other, and both offer different benefits, as was emphasized by Burns (1999).

As Marshal and Rossman (1999) state that qualitative study offers more information, the reasons for choosing specific answers, as well as the respondents' opinion of certain experience. Whereas quantitative method which refers to questionnaire in this research supports the researcher to collect more data about various issues in a shorter time (Cohen et al., 2000). In other words although, questionnaire includes many questions about different issues, the respondents may not feel free in answering them. Also it is possible to investigate and implicate people from diverse geographic areas and it is easy to analyze the data through using technology and computer software packages, for example, Microsoft office and Excel.

Eventually, to avoid being biased, Likert scale or multiple choice questions were used because the researcher has no role in affecting the participants' view and all the nominees reply the same questions under the same conditions (Seliger and Shohamy, 1989).Furthermore, in the first section some questions had 'others' as an option in order to participants write their answers if it was different from the options.

One more point is that questionnaires have some as disadvantages as well as advantages as Dornyei (2003) and Bell (2002) suggests the researchers' duty to design the questionnaire and examining the data carefully. For instance the respondents may choose an answer or agree to a statement to satisfy the researcher. Another drawback is the low return rate. Respondents might forget about the procedures and overlook shelve them.

3.6 The Purpose and Content of the Study

Almost all the questions reflect the content of the study also selected are connected to participants' basic evidence. Based on some earlier studies and researches in different reigns in the world, in addition to the researcher's experience as an engineer in NI, some new questions were designed to be appropriate to the content and the new context of the study.

The aim of this study is to answer the research questions and explore the experience of the LC method using LPS implementation in NI and its success rate in the future.

3.6.1 Piloting the study

Piloting is one of the significant steps of any study because it assists the researcher to get more information from the participants to design more relevant question and suitable options to improve the questionnaire before releasing it. Likewise, it helps to

make the questionnaire appropriate according to the devoted time, environment and sometimes the political and the economic situation of the country in which the researcher conducts the study. Hedrick et al. (1993) asserts that piloting facilitates testing the whole procedure, such as, indicating the time which is wanted to ample the survey and designing clear and comprehensible questions for the candidates.

Also, Oppenheim (1992: 47) claims that in each study aspect should be examined previously in order to make sure that it matches the researcher's. Brown and Rodgers (2002) support Oppenheim and assert, "That experimental education is a vital component of a reliable education". In addition Dornyei (2002) points to the significance of experimental education and state that removing this stage of any study may affect the validity of the outcomes.

Based on the views expressed previously by different academics, the researcher piloted the education with some people. They gave useful feedback to recover the survey. For instance, a participant recommended adding "do you have experience with the LPS". Taking their feedback into consideration, the researcher edited some of the options as well. Also after consulting with the research supervisor, question number eight which deals with the factors that stimulate the implementation of the last planner factors has been added in addition to a case study. The required time to fill the survey was from 12-18 minutes whereas for the interviews the period was diverse between 17-32.

3.6.2 Interviews

It had been noted that the interviewee was trying to give an academic speech instead of answering the questions specifically. The respondent was trying to modify

answers whereas the content was neglected. So the researcher changed the strategy, instead of interviewing in English the interviews were conducted in 'Kurdish' to avoid embarrassing those who do not know English and make the interviewees feel more confident and realize that the content of their answers is important not the academic words that they use.

The interviews were approximately about 25 minutes extended. The talks were arranged in various places; the participants' home and their workplaces. Additionally, the first question for all the interviewees was 'Do you mind if your answers are used for research purpose anonymously?' and all the interviewees gave their approval.

Moreover, it is worthy to mention that in spite of using the same questionnaire, the talks were semi-structured because sometimes both the researcher and the evaluator were going into more detail. As Berg (1989) asserts, when the interviewees were given choice to answer, they give more accurate answers. All the talks were detailed and then analyzed by the researcher.

3.6.3 Case study

Case study is a useful tool to study a topic in further detail. As Zainal (2007:5) suggests, "Case studies are well-thought-out useful in the study as they enable researchers to inspect data at the micro level". The case study in this research will be presented according to the research supervisor's suggestion in order to enrich the research and study the subject in further detail and within a specific context. This case study is the researcher's personal experience of LC using the LPS in a building project in the NI during doing a research as a final requirement of postgraduate study. The researcher executed his knowledge about LC using LPS in that project

because of his admiration of this system and being aware of its advantages. This experience's results and outcomes will be analyzed in chapter four and the schedule will be presented in appendix.

3.6.4 Content of the Questionnaire

The questionnaire was designed by using Google forms. Also most of the closed end questions were designed with four points rating scales. It was believed that a good-looking survey may encourage the contributors to response all the queries luckily. Based on this idea and the investigation inquiries, the questionnaires' items were gathered:

- The participants' general information was the first section of the questionnaire. For instance, gender, age, their job position, the organization they work for and the length of their experience in construction industry. However NI is a developing country and there are few construction companies operating in the sector, but the participants fulfilled the conditions required for the survey.
- The second section was about LC and the LPS to find out if the participants have information about implementation of this method because it is a new method especially in the NI. In this section the participants were asked to stop completing the questionnaire if they are unfamiliar with this method.
- The third part was structured to investigate the causes of waste and the ways to reduce it in addition to implementation of LC and the LPS.

All the items were grouped as it was mentioned before and every group was followed by some sub-divided questions. Most of the questions had four thinkable answers which are reached from No effect, Low effect, Medium effect (Mid effect), and

Large effect; strongly disagree, disagree, agree, and strongly agree. Also some questions are multiple choice questions with different options.

Finally, the questionnaire has structured to cover only relevant questions to the content of the study.

3.7 Data Collection and limitations

A challenging process of this research cause of various places where the participants live or work in, and lots of them were exciting with their job. 23 of them had filled out the hard copy of the survey and they were agreed the casual to ask for clarification of any confusion while 37 nominees received it via email. The overview section was including the academic's email and telephone number so the respondents could communicate if they confronted with any difficulties concerning thoughtful the content of the questions. From those 37 surveys and after one week days only 29 finished forms were returned back. Two of them were detached because one of the respondents left two of the inquiries unrequited and the other one left the information blank.

3.8 Data analysis

After collecting all the accomplished surveys, the outcomes were computed and analyzed by means of using Excel software. In addition to the questionnaires' analysis, the interviews were analyzed and explained by the researchers in data analysis chapter respectively.

3.9 Summary of the Chapter

This part acquired the exploration questions and speculations, the candidates and the sample size, and the system which is used in this survey study, for example, survey, contextual investigation and meeting. Furthermore, steering the study was another

subject which has been introduced. Moreover, this section secured the information gathering methodology and examination. The following part will display the usage of this procedure in an observational study in the NI and its discoveries notwithstanding their connection with the hypothetical segment of the exploration.

Chapter 4

RESULT AND DISCUSSION

Depending on the case study, questionnaires and the interviews, this chapter presents the findings of the study. Following a case study to implement LPS by the researcher 50 candidates completed the questionnaire and five of those participants participated in the interviews which one of them was the group interview. According to the questionnaire's format the results are divided into three categories. It was decided to go through each question separately because it was noticeable this may contribute in better understanding of the participants' viewpoint and knowledge about LC using the LPS.

1. The first classification is general information about the participants.
2. The second type deals with the outcomes of the participants' knowledge about LC using the LPS.
3. The third category deals with the results of the causes of waste, the ways to reduce it and the effects of the LPS in reducing waste.

4.1 Section One: Practical Study Findings and Discussion

4.1.1 The case study

4.1.1.1 The Project

The LPS was implemented in a governmental construction project. The project is (Raniyah 132/33/11 KV Substation building) located on the Kurdistan Region of Iraq, having a projected contract value of 543,145.76 US Dollars. The opportunity of the project complex construction of 2 multi-story building with 200 m² garden and a

welcome room.

The area of the building is 711.36 m2, so the building is divided into two joints in the longitudinal direction. All projects was allocated 12 and 13 months construction time frame respectively with 20 months of overall project duration.

An initial meeting was held with the venture group in June 2015, and a few other subsequent gatherings took after over the ensuing three months to create and concur upon the LP approach. It was clear that both the PM and the organizer took dynamic activities in utilizing LP as one of various instruments to convey on a tight development plan.

The gatherings included the PM, organizer, administrators, undertaking specialists, field engineers, sub-contractor and foremen with a General Contractor (GC), so that an extensive variety of staff had a comprehension and enthusiasm for the advancement and usage of the LP approach.

4.1.2 The Implementation of LPS Strategy of the Project

The research plan was to execute the implementation process in four stages as shown in Figure 4.1. This additional implementation is due to the belief that it gradually stabilizes the features of LPS, reduces resistance to modification, and ensures further opportunity to assess each step and gain experience for future projects.

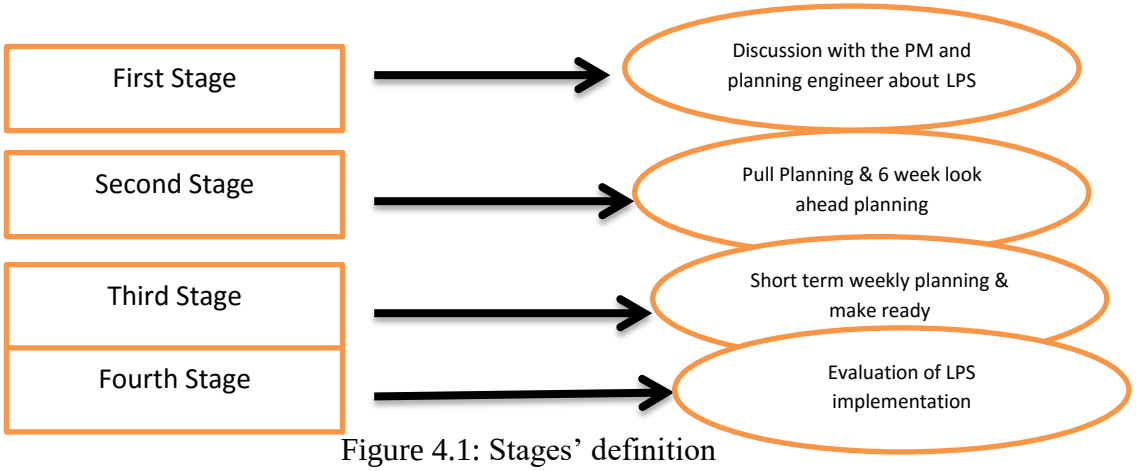


Figure 4.1: Stages' definition

4.1.2.1 Stage one

The first stage was to provide the team with information about LC using the LPS and discussing the anticipated advantages of LC and LPS through a workshop also training them to implement this system. Then, the participants were observed for two weeks in order to monitor the present planning rehearsal through interviewing them and taking notes.

Furthermore, training the team to learn the most effective method to ascertain the PPC, detecting failure reasons throughout these two weeks was another goal of this stage however; this is excluded in the information because LPS was not executed throughout that period. In addition to calculating PPC in this stage also the reasons behind uncompleted assignments were outlined and recorded.

4.1.2.2 Stage two

In this stage, the Phase Pull Planning (PPP) as one of the key components of LPS was implemented. Also all project parties such as, contractors, managers, field supervisors; client representatives, consultant engineers, and subcontractors

participated in two weekly meetings.

In addition to implementation of the WWP and Make Ready, another crucial component of LPS, LAP was applied as well. In the case study project, LAP planning was a unified six-week window. It was removed from the Master Plan (MP) of a project and then synchronized in the LP. Likewise, for the phase planning sessions were held in order to deliver certain objectives and afterward worked reverse from the objective accomplishment date to accomplish the intended signs. Respectively the sessions were respectively devoted to certain categories of activities.

Based on the durations calculated previously for each item, the project plan was preparing by using MS Project & Primavera. And also the proceedings of activities were based on our engineering experience.

LP prepared major milestones for diverse activities and then the participants worked backward to attain target achievement date of these goals. The procedure was performed through posting activities on the wall, later changed to detailed Gantt chart by the company planner using MS Project and Primavera P6 for the building construction of the project as shown in Figure 4.2 and Figure 4.3.

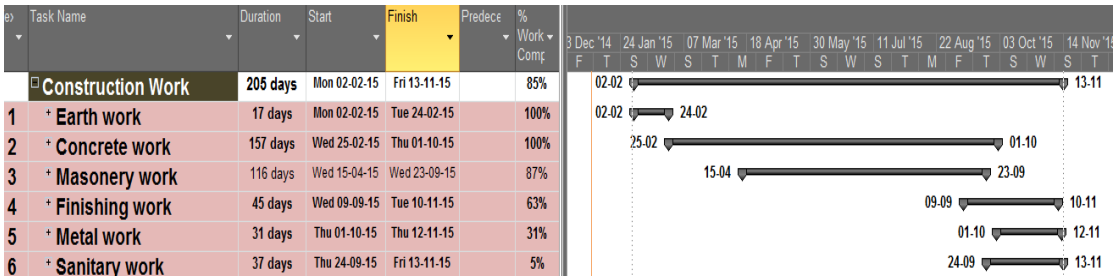
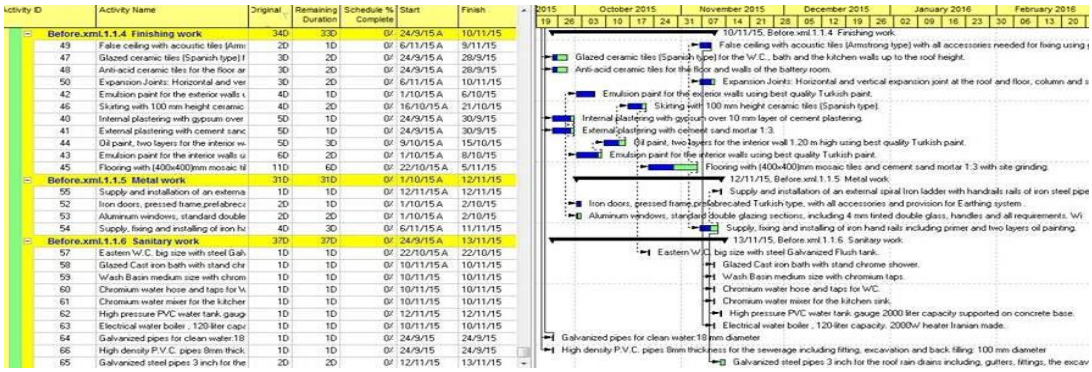


Figure 4.2: PPC by MS project



Activity ID	Activity Name	Original Duration	Remaining Duration	Schedule % Complete	Start	Finish
Before.xml.1.1.4	Finishing work	34D	33D	0%	24/9/15 A	10/11/15
49	False ceiling with acoustic tiles (Arm	2D	1D	0%	6/11/15 A	9/11/15
47	Glazed ceramic tiles (Spanish type) f	3D	2D	0%	24/9/15 A	28/9/15
48	Anti-acid ceramic tiles for the floor ar	3D	2D	0%	24/9/15 A	28/9/15
50	Expansion Joints: Horizontal and ver	3D	2D	0%	6/11/15 A	10/11/15
42	Emulsion paint for the exterior walls u	4D	1D	0%	1/10/15 A	6/10/15
46	Skirting with 100 mm height ceramic	4D	2D	0%	16/10/15 A	21/10/15
40	Internal plastering with gypsum over	5D	1D	0%	24/9/15 A	30/9/15
41	External plastering with cement sanc	5D	1D	0%	24/9/15 A	30/9/15
44	Oil paint, two layers for the interior w	5D	3D	0%	9/10/15 A	15/10/15
43	Emulsion paint for the interior walls u	6D	2D	0%	1/10/15 A	8/10/15
45	Flooring with (400x400)mm mosaic til	11D	6D	0%	22/10/15 A	5/11/15
Before.xml.1.1.5	Metal work	31D	31D	0%	1/10/15 A	12/11/15
55	Supply and installation of an externa	1D	1D	0%	12/11/15 A	12/11/15
52	Iron doors, pressed frame,prefabrecz	2D	1D	0%	1/10/15 A	2/10/15
53	Aluminum windows, standard double	2D	2D	0%	1/10/15 A	2/10/15
54	Supply, fixing and installing of iron ha	4D	3D	0%	6/11/15 A	11/11/15
Before.xml.1.1.6	Sanitary work	37D	37D	0%	24/9/15 A	13/11/15
57	Eastern W.C. big size with steel Gal	1D	1D	0%	22/10/15 A	22/10/15
58	Glazed Cast iron bath with stand chr	1D	1D	0%	10/11/15 A	10/11/15
59	Wash Basin medium size with chrom	1D	1D	0%	10/11/15	10/11/15
60	Chromium water hose and taps for W	1D	1D	0%	10/11/15	10/11/15
61	Chromium water mixer for the kitcher	1D	1D	0%	10/11/15	10/11/15
62	High pressure PVC water tank, gaug	1D	1D	0%	12/11/15	12/11/15
63	Electrical water boiler , 120-liter capa	1D	1D	0%	10/11/15	10/11/15
64	Galvanized pipes for clean water:18	1D	1D	0%	24/9/15	24/9/15
66	High density P.V.C. pipes 8mm thick	1D	1D	0%	24/9/15	24/9/15
65	Galvanized steel pipes 3 inch for the	2D	2D	0%	12/11/15	13/11/15

Figure 4.3: Primavera & PPC

All main subcontractors; i.e., mechanics, electricians, plumbers, architectures, and fire bridges attended these sessions which were planned two months earlier than the actual origination of project. Also key workforces such as, owner, designer and general contractor participated these meetings, too and were informed with a review of the procedure. The subcontractors' responsibility for pulling out period and accurate sequencing of construction activities were distinguished through color coded system. Figure 4.4 and Figure 4.5 are the photographs taken during PPS sessions held at the contractors' office.

Figure 4.4: Coordination of Construction Sequence on Billboard

Figure 4.5: Outcome of PPP Meeting

4.1.2.3 Stage three

Third stage was the longest stage. Applying LPS on location was aided by the researcher and it was proofed that PPC and explanations behind uncompleted tasks can be founded and noted on a week after week premise for twelve weeks dated. It was an effort to assist the group to see how the LPS added to the developed the proses of planning. In this stage, the emphasis chiefly was on fleeting arranging and Make Ready and LAP increased little consideration.

Weekly meetings in this stag had their importance and participation of all plan gatherings (subcontractors, constructors' side, and customer legislatures). This stage, PPC and details behind uncompleted responsibilities were composed at the end of seasonal and start of fall period in the NI. At his period of the year, the maximum fever is generally noted, and in 2015 in the day time it reached 112 Fahrenheit degrees.

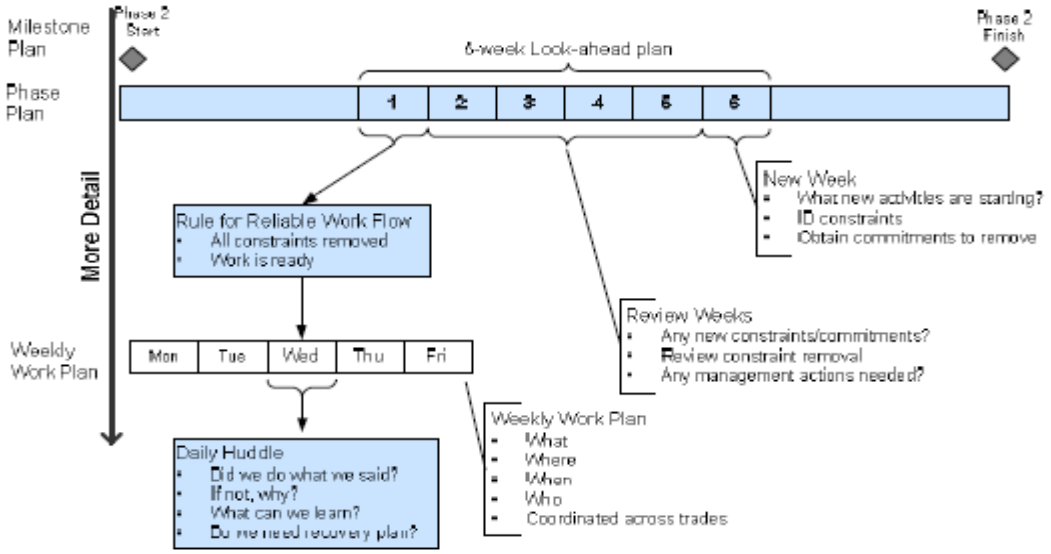


Figure 4.6: Preparing WWP from 6 WLAP

4.1.2.4 Fourth Stage

This stage mainly concentrated on a questionnaire designed to assess the LPS implementation procedure and allow the respondents to express their views about the attained advantages, Critical Succeed Factors (CSFs), and obstacles in front LPS application in the plans. The participants were given adequate time to read and through the questionnaire, their answers and ask for clarification. Some of them participated in a group interview (with an informal and friendly discussion context) with the presence of the researcher. The questions were explained and the participants were given the required clarification. Then, the nominees were inquired to select the answers which they believe according to their opinions.

The questionnaire contained a section related to the reached advantages, CSFs and difficulties for LPS application were designed using a four-point scales which asking for the participants' opinion about different characteristics of the LPS assembled from the result of previous studies and literature review about the LPS and Lean

Construction in chapter two in addition to, the notes taken during the researcher's involvement in the implementation the method. *See Appendix - A* for the survey questionnaire.

4.1.3 Weekly Percent Plan Complete (PPC)

In the first week the project's PPC gradually rose from 60%, peaked at 88% in the fourth week, and after 12 weeks it reached 83%. The project's average PPC was 73% compared to 62%.

Ballard (2000) defines PPC as, a degree of workflow dependability and it is measured by separating the amount of completed near-term assignments completed by the overall number of assignments designed for the plan period.

Required data for PPC control are “in the sum of assigned tasks and the number of completed tasks”. They are acquirable from the project foremen and engineers without any extra time, effort or additional monitoring such as resource consumption which is necessary for this measurement.

The researcher played as a facilitator during implementing LPS over thirteen weeks period at a building project, in addition to collecting data for PPC ratio's peer review. The collected weekly data from the field was analyzed and computed in three different PPC ratios. Each of these ratios shows a different layer of contractor's weekly plans reliability compared to the 6WLAP and the standard schedule or PPS.

The following steps are the detailed process used to gather and analyze the data, which were achieved during the weekly sessions with the subcontractors:

1. Study the model schedule and excerpt the activities that should be executed during the following weeks. The SHOULD list of work assignments was generated in this step.
2. Study the monthly schedule and excerpt the activities that should be performed during the following weeks and taking the resource and space availability into consideration. This step produced the ADJUSTED SHOULD list of the assignments.
3. This step represents the WILL list. It is planned to study the project supervisor's intend to improve the work list assignments for the following weeks taking other factors into consideration such as, the quantity of resources and space availability, in addition to shop drawings status.
4. Monitor the definite implementation of work items covered in the WILL list.
5. Discussion among the project superintendent and engineers about the work completed during the week generated in the WILL list for the succeeding week (step 3). The below items were reviewed in the weekly sessions:
    a) Include the Percent Complete (PCT) of each activity that the contractor worked on during the week has just ended of the WILL assignments.
    b) WILL activities within a PCT more than 50% in PPC calculation are given 1 as a value while the activities with less than 50% are given 0. This random evaluation represents a key departure from LPS definition (a value of 1 for 100% PCT and otherwise 0),
    c) Evaluate and plan the PPC ratios for the ended week based on the definitions of Table 4.2.
    d) The activities that assigned a value of 0. I.e. uncompleted WILL

activities are studied and the reasons for incompletions are recorded.

Table 4.2: Percent Plan Complete (PPC) Definitions

Ratio	**Definition** **(The ∩ symbol performs an intersection of two lists)**	**Meaning**
PPC1	$\frac{\text{DID} \cap \text{WILL}}{\text{WILL}}$	How the as-built compares to the WWP
PPC2	$\frac{\text{ADJUSTED SHOULD} \cap \text{DID}}{\text{ADJUSTED SHOULD}}$	How the as-built compares to the 6WLAP & 3WLAP
PPC3	$\frac{\text{SHOULD} \cap \text{DID}}{\text{SHOULD}}$	How the as-built compares to the baseline schedule

4.1.4 PPC Ratios

The PPC 1 ratio displayed in Figure 4.7, is the outcome of number of activities completed in compare to tasks listed on WWP, characterizes developed planning reliability. The average of 73% of PPC1 ratio for the project, indicates that about three out of four estimated weekly activities were worked on, i.e., assignments in the WILL list reached a PCT of more than 50%. This short-term look-ahead ratio illustrates developed planning performance after application of LPS.

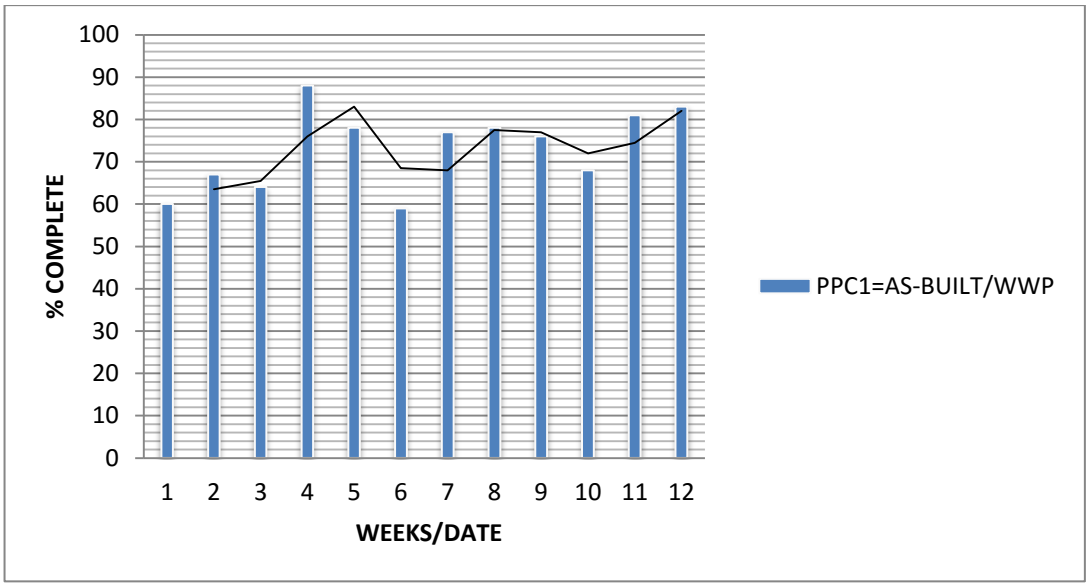


Figure 4.7: PPC1 Ratio for As-built & WWP

The PPC2 ratio presented in Figure 4.8, is the result of number of activities completed in Compare to those listed on 3WLAP, describes planning application during the project period. The PPC2 ratio of average of 62% shows that two out of three expected weekly activities were actually worked on, i.e., more than 50% of the activities in the WILL list were achieved. This short-term look-ahead ratio proposes that the current week-to-week planning needs development in order to avoid time overrun.

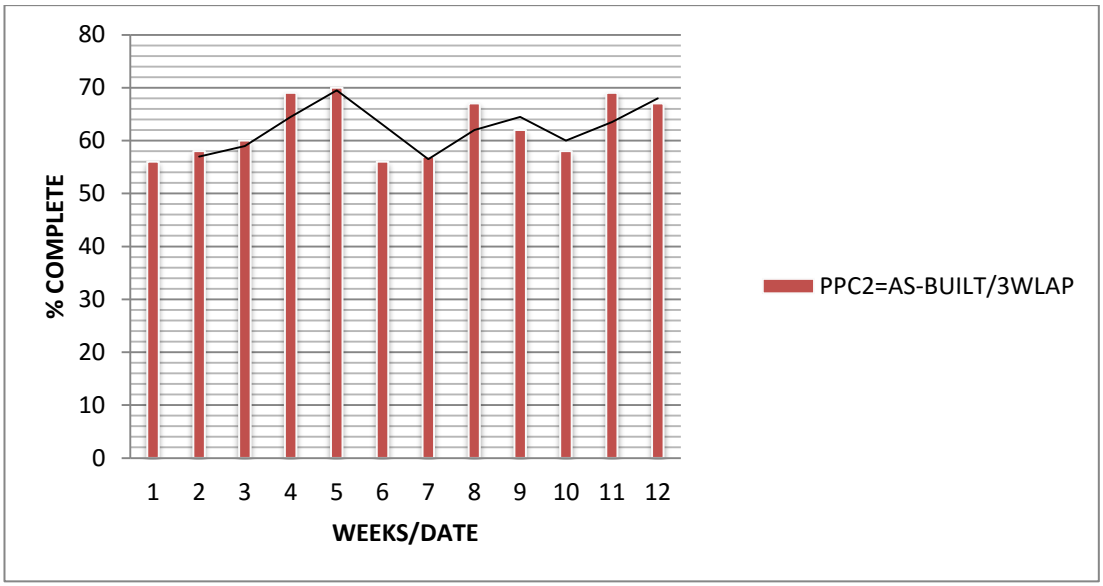


Figure 4.8: PPC2 Ratio for As-built & 3WLAP

The PPC 3 ratio presented in Figure 4.9 is the result of number of activities completed in compare to the list of activities on Baseline Schedule (BS), demonstrates planning performance of the project's master schedule. The PPC3 ratio of 50% average indicates that one out of two expected weekly activities in the WILL list were worked on and achieved a PCT. This short-term look-ahead ratio recommends that the present master schedule requires a lot of developments to attain satisfactory results.

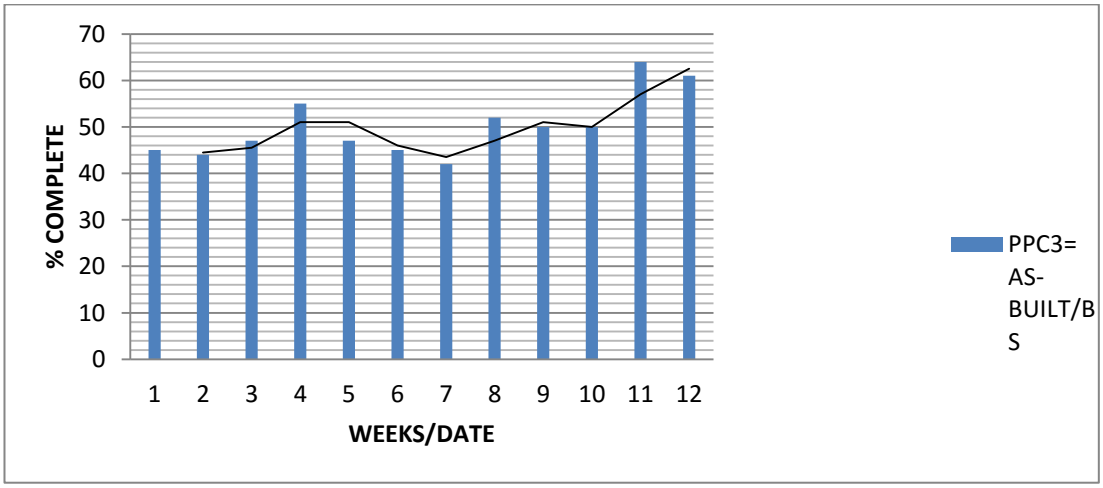


Figure 4.9: PPC3 Ratio for As-built & BS

4.1.5 Reasons for Incomplete Assignments

Figure 4.10 demonstrates the numerous behind uncompleted activities expressed for the benefit of the undertaking. Pre-required work was the key factor for deficient assignments in the task. This perhaps, because of the components of the level that the undertaking had achieved as most assignments; including building activities were completely depending on finished auxiliary assignments. For the purpose of comparison, reasons for incompleteness were combined in the same figure.

Labor supply was the first significant reason for incomplete assignments of the same project. The project appeared to struggle to keep pace with the arranged plans such as; weekly plans and LAP because of insufficient available workforce to encounter the plan's requirements. Many of the subcontractors appear to need surpassed their abilities to provide labor supply and this is because of the market's popularity for gifted labor recently, as the nation is going through extraordinary development blast and billions dollar ventures have been continuing and numerous more are in the arranging stage by both the state and private segments.

Another primary explanation behind the project incompleteness was the materials accessibility, which arose du to a few elements. Firstly, the endorsement process which was essential by the customer was timewasting and brought about deferrals. Besides, delay in delivering materials by the suppliers or sometimes delivering wrong materials. In this case deliveries were made but with wrong materials and this occur mostly due to supplier's confusion because of existing many types of blocks such as; standard, cement or ponza and many block sizes being used. Also in some other cases, precisely during the last stage some of the mechanical materials supplies

were simply delayed.

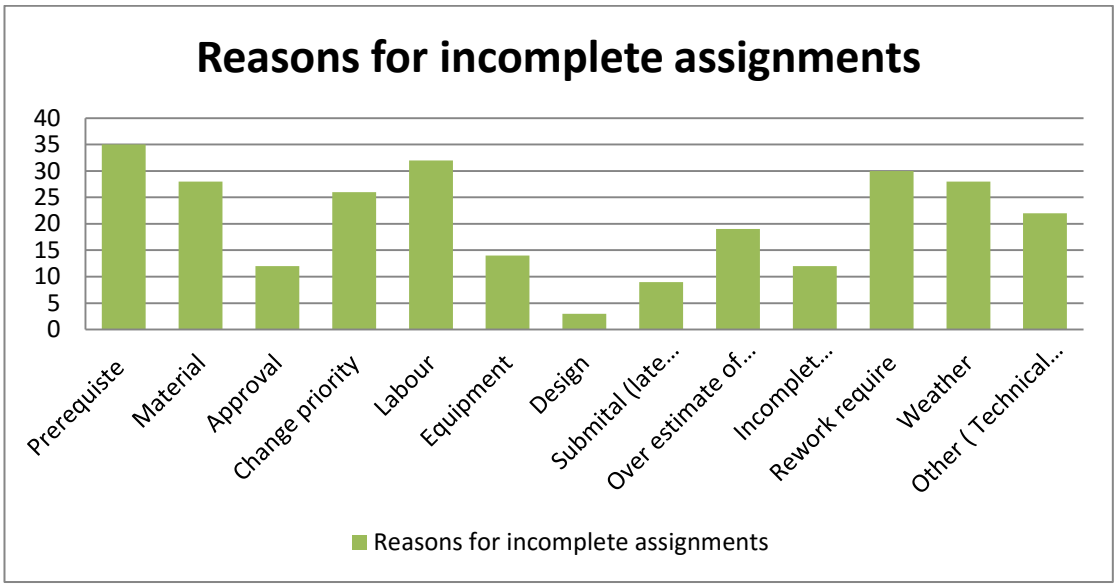


Figure 4.10: Reasons for uncompleted tasks over the entire Period of the Project

The third reason was identified with endorsement, since the endorsement framework by the customer itself brought about deferrals because of organization and the use of research material as an exclusive mean of communication in material purchase agreement. Additionally, there was an issue with delay in starting activities due to late submitted requests to be decided on them.

The fourth reason was changing needs, which generally showed up in the design assignments that were not really succession subordinate. Nevertheless, in a few circumstances it was important to change need due to works appropriation among the zones, disarray in assets conveyance, accessibility of experts, for example, constructors and woodworkers, furthermore there might have been different reasons. The fifth huge reason was equipment delay and submitting late of requirements as they were similarly occurred five times over the whole time of LPS execution.

Factors affecting waste and implementing LPS in the NI, this might relate to the political and cultural issues. Similarly, the results provided evidences of advantages of planning process. At the end of the empirical study, the researcher concluded to provide the following framework as it is seen in Figure 4.11.

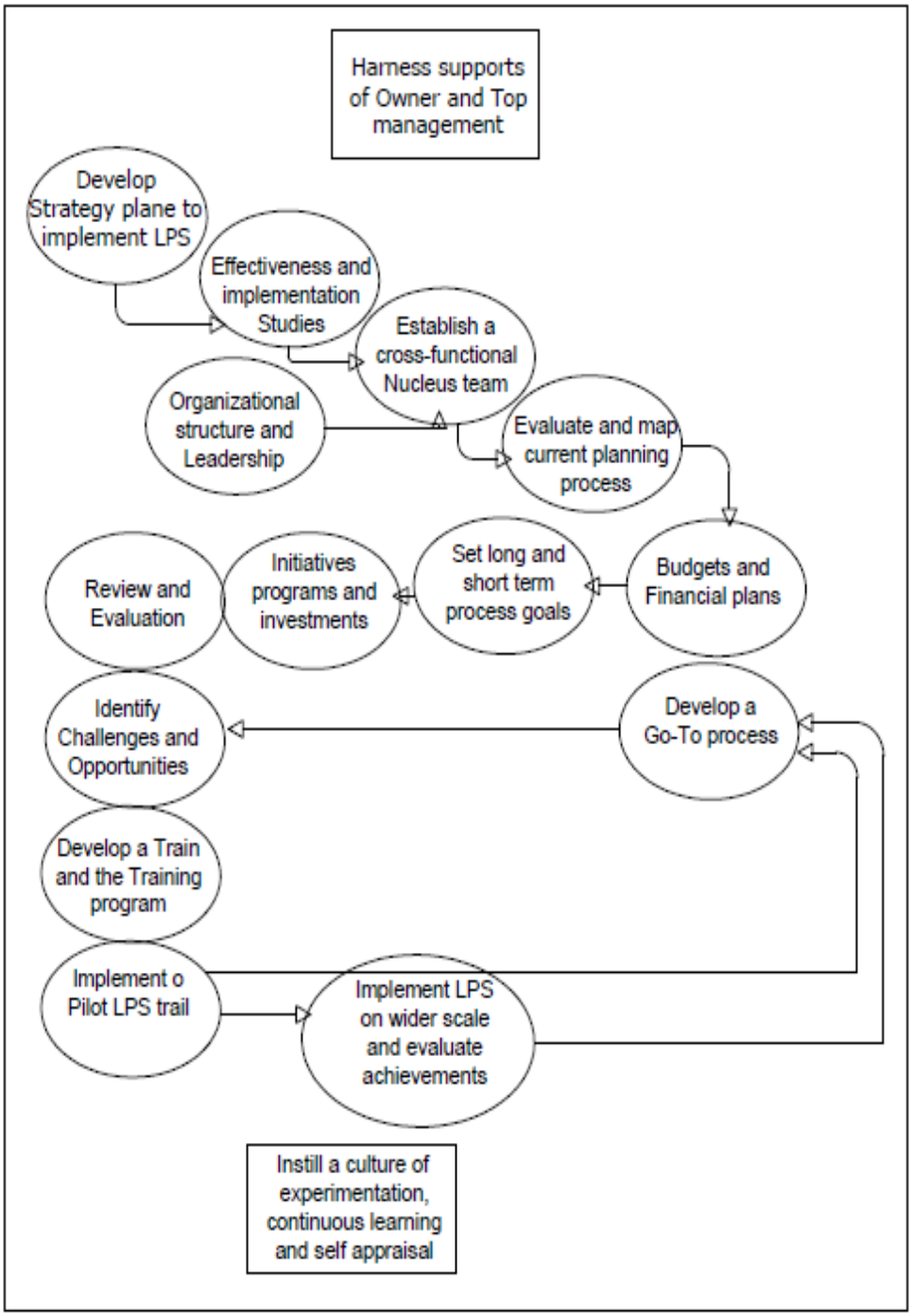


Figure 4.11: Suggested framework for implementing the LPS in construction.

4.1.6 Summary of the case study

LPS was implemented on a building in four stages (i) LPS training, (ii) PPS sessions, (iii) Development of 6 WLAP and WWP, (iv) PPC calculation and (v) LPS implementation evaluation process supported by interviews and questionnaire.

4.2 Section Two: The Questionnaire and Interview

4.2.1 General information

This section includes some information about the nominees so as to make unquestionable that they meet the requirements of the study.

4.2.1.1 Gender

This questionnaire was given to both males and females since gender has not gained interest of this study. Since female engineers are very few in NI, 9 female (18%) and 41 males (82%) completed the questionnaire as shown in the Figure 4.12.

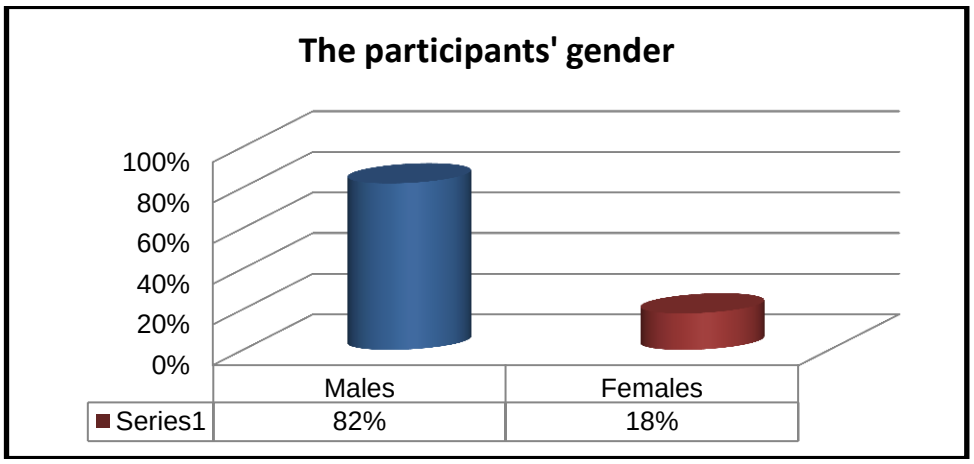


Figure 4.12: The participant's gender

4.2.1.2 Age

This was not the concern of the research but this inquiry was requested to be certain that all the participants are in the right age and meet the requirements. 8% were 18-24, 52% were 25-34, 30% were 35-44 years old and 10% chose 45 or more as shown in the Figure 4.13.

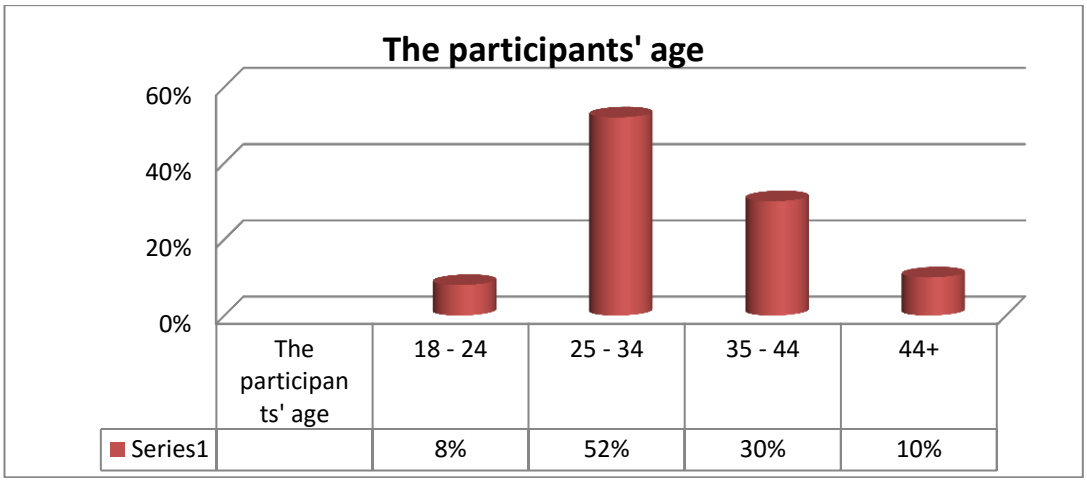


Figure 4.13: The participants' age.

4.2.1.3 Work Places of Participants?

Regarding the third question, 56% of the participants said that they work in private sector while the other 44% of them work in state organizations, such as, educational institutes and state ministries and their project departments shown in Figure 4.14.

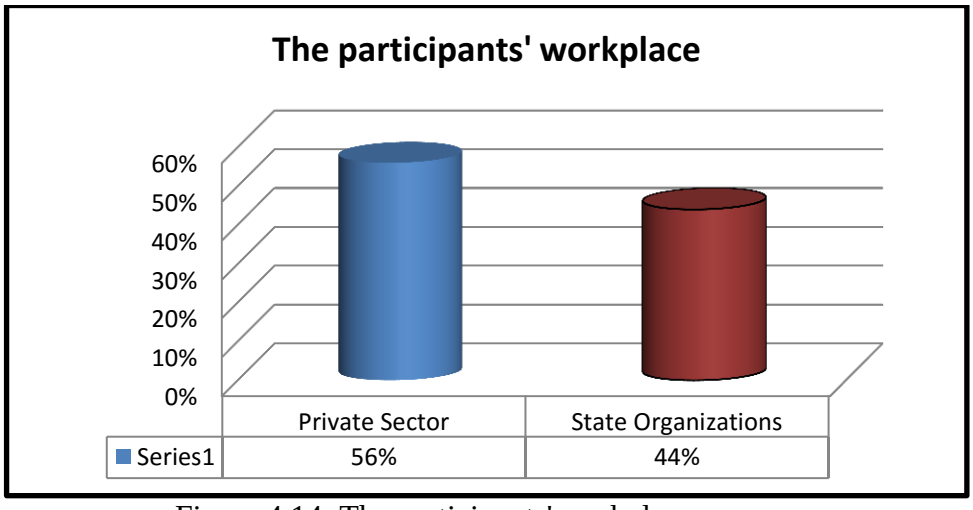


Figure 4.14: The participants' workplace.

4.2.1.4 Education Level of Participants?

12% of the participants had PhD, 24% had MSc, 40% had BSc, and 24% of them chose others because some of them had no qualification or had different qualification

but they work in construction industry and have different positions as shown in Figure 4.15.

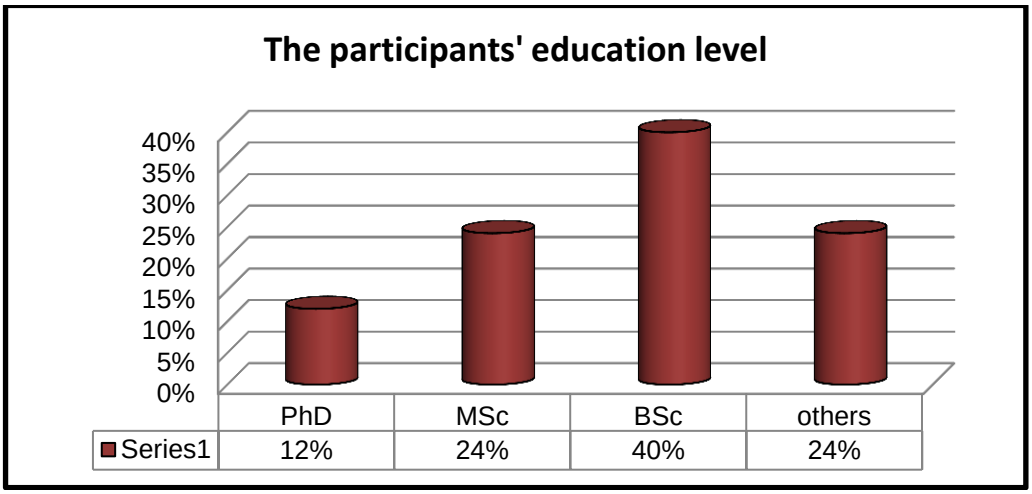


Figure 4.15: The participants' education level.

4.2.1.5 Position of Participants in industry?

Moreover, regarding the participants position within industry, 16% of these participants were contractors, 8% were subcontractors. This option was written because in NI many contractors resale the contracts or employ other people to supervise the work for them, those people are called subcontractors. They buy it from the main contractors or rent it because they have no power or not famous to get it directly or sometimes the contractors do not have energy or enough time for that project. 32% were site engineers, 12% were project managers, and 32% chose others and wrote they work as teachers in educational institutes shown in Figure 4.16.

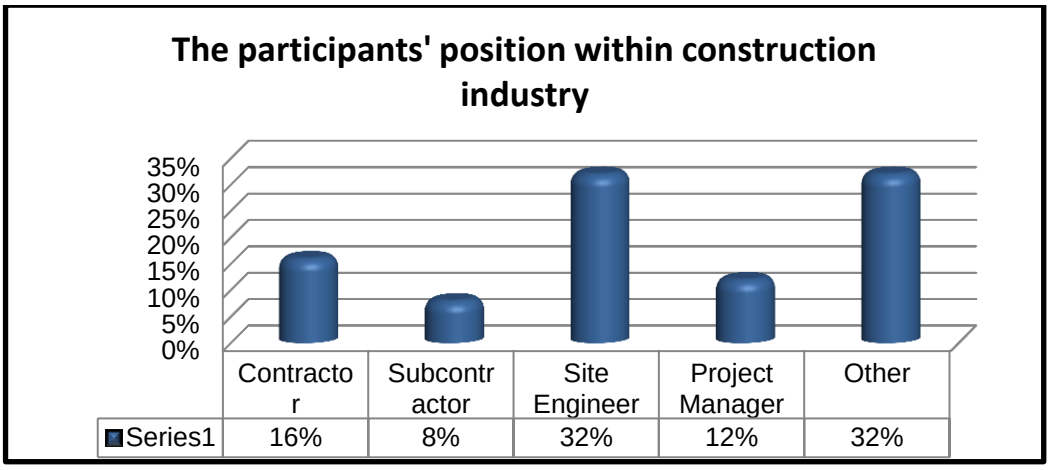


Figure 4.16: The participants' position within construction Industry

4.2.1.6 Type of Organization?

Concerning the sixth question the participants were asked which organization they are working for, 28% of them chose contracting, 16% of them said that they are working in educational institutes and the other 56% states that they work as teachers, site engineers, checking designs and project supervisors as shown in Figure 4.17.

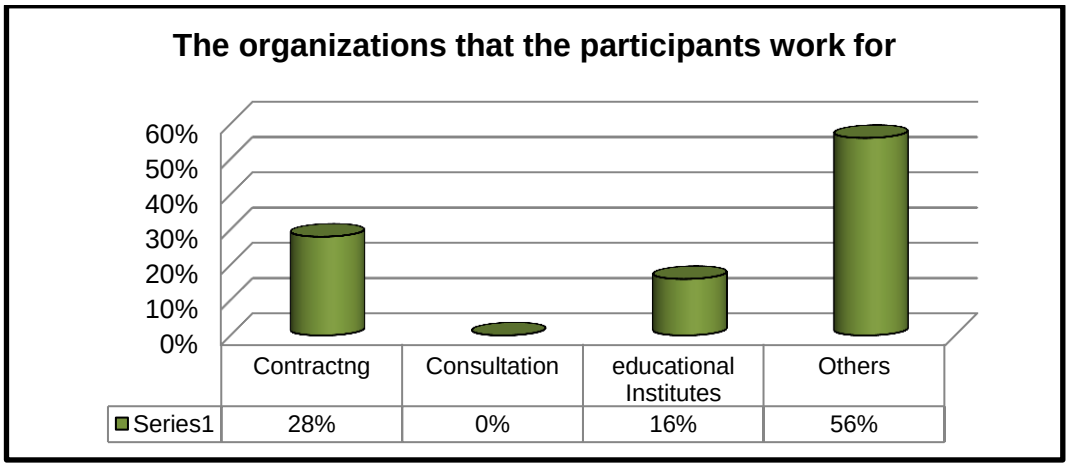


Figure 4.17: The organizations that the participants work in

4.2.1.7 Experience within Construction Industry?

The last question in this section was about the participants experience within industry. 4% of them had less than one year experience, 8% chose 1-5 years' of

experience, and 66% of them had 5-10 years of experience while 6% percent had more than 20 years of experience as shown in Figure 4.18.

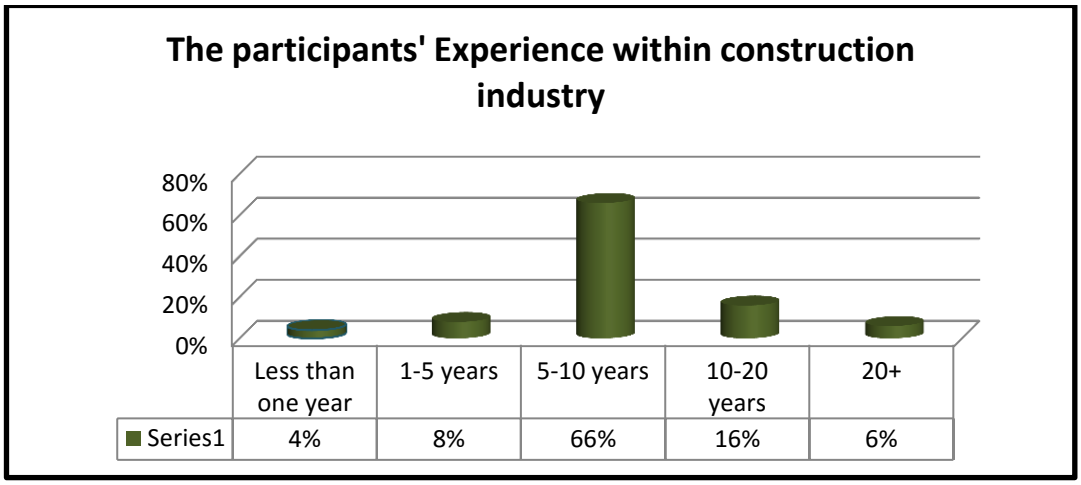


Figure 4.18: The participants' experience within construction industry.

4.2.1.8 Summary of the participants' general information

The results of this section show that the participants are in the right age and had enough experience to express their viewpoints and complete the questionnaire with true and reliable information.

4.2.2 LC Experience

Experience with LC was the second part of the questionnaire of this study. In this section, participants' experience with LC will be measured through asking them about the years of their experience and their approval of this experience. In addition, the participants were asked to stop filling the questionnaire if they were unfamiliar with this new system.

4.2.2.1 Experience with the LC?

It was expected that Kurdish engineers and all those who work in construction industry have no information about LC 48% of the participants chose "no" as they did not have experience with LC, as one of the interviewees asked "What is LC?"

while surprisingly another one stated that “I know what LC is, but never had chance to implement it because of lack of support and needed materials”. This means that some of the participants have information but no experience. On the other hand, 52% of the participants said that their experience is less than one year as shown in Figure 4.19. Since none of the participants chose 1-3 years or more than 3 years, this means this system is recent in NI and this might be the main reason behind the participants' lack of information or experience with this system.

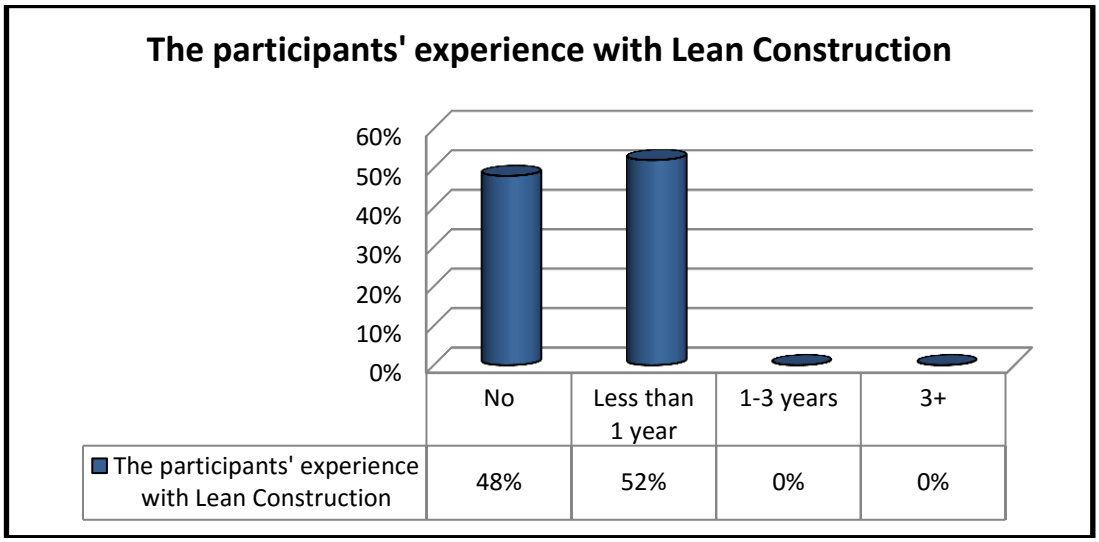


Figure 4.19: The participants' experience with Lean Construction

4.2.2.2 Having Information about LPS?

To answer this question 56% of the participants said that they have information and as it was explained in the previous questionaries’ 52% of them had experience but the other 44% had no information as shown in Figure 4.20. However this result even higher percentage was expected but this might create some problems and difficulties in the findings because there might be a few people to complete the third part of the questionnaire.

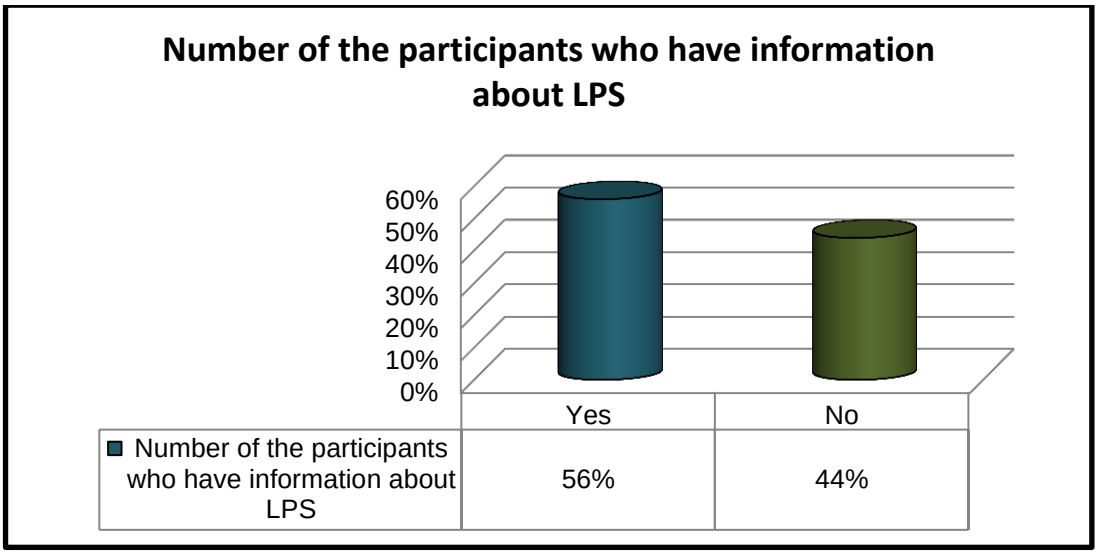


Figure 4.20: The Percentage of those participants who have information about the LLP

4.2.2.3 The Results Achieved, Satisfactory or Not?

Regarding this question the participants were asked to rate their satisfaction with LC using the LPS. The options for this question were 1 (the least Satisfactory), 2 (satisfactory), 3 (more satisfactory) and 4 (the most satisfactory). Although all those 28 participants who continued completing the questionnaire after the second question in this section were satisfied with the results, their fulfillment was not high as 71.4% chose the least satisfactory and 28.5% chose satisfactory whereas no one chose more satisfactory or the most satisfactory as shown in Figure 4.21. Moreover, one of the interviewees claimed that his experience was not very satisfactory because he had faced many difficulties. This might be applicable for other participants as well.

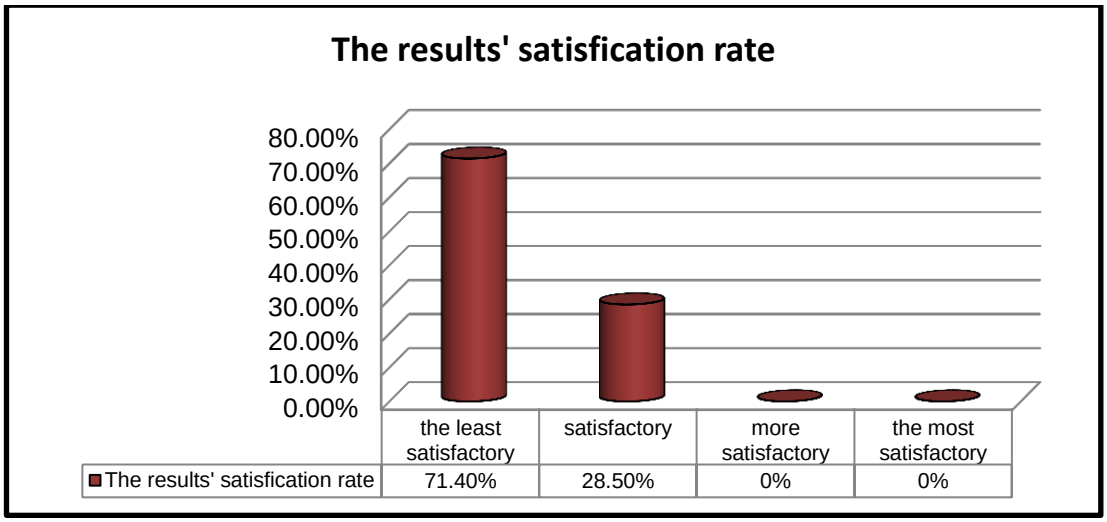


Figure 4.21: The results satisfactions rate

4.2.2.4 Summary of the Participants' Experience.

The results showed that the participants' experience with Lean construction is low. However the results revealed that about half of the participants do not have experience with LC using the LPS and some of the participants had information about LC using LPS but not all of them had experience with its implementation. Moreover, those who had information, their information or their experience was limited which was not enough to satisfy them due to the reason that this system is new and its execution might confront with many difficulties. In general the results demonstrate that there is a link between the results and the researcher's hypothesis that all the participants may not have information.

4.2.3 LC using the LPS and Other Factors in Solving Construction Problems

This unit of the survey was depend on two of the investigation inquiries in order to discovery the causes of waste in construction industry in NI and the factors that contribute in reducing waste according to the participants' point of view. Additionally, this section deals with the complications and supports in executing this system. Furthermore, this section tried to find to what extend the participants suggest the implementation of this system in NI. In addition, it attempts to indicate the

relation between the participants' viewpoint in the NI and the existing literature in LC using LPS domain. This section included 7 questions. 5 of the questions were divided into sub-questions and the other two questions were multiple choices.

4.2.3.1 What are the Effects?

1. **Idle Time (Time between activities)**

The responses showed that all those participants who are aware of LC, all agreed that idle time affects the project as no one said it has no effect or few effect but 7.1% chose mid effect and the other 92.8 chose large effect. Also one of the interviewees said that idle time is a big issue in many projects in the NI as it wastes time and money and causes delay as shown in Figure 4.22. This interviewee related this problem to some other factors such as, breaking down equipment, lack of needed equipment and skilled staff on time and sometimes political issues, the weather and the roads' conditions cause material flows delay as a result the project will be stopped for unspecified time.

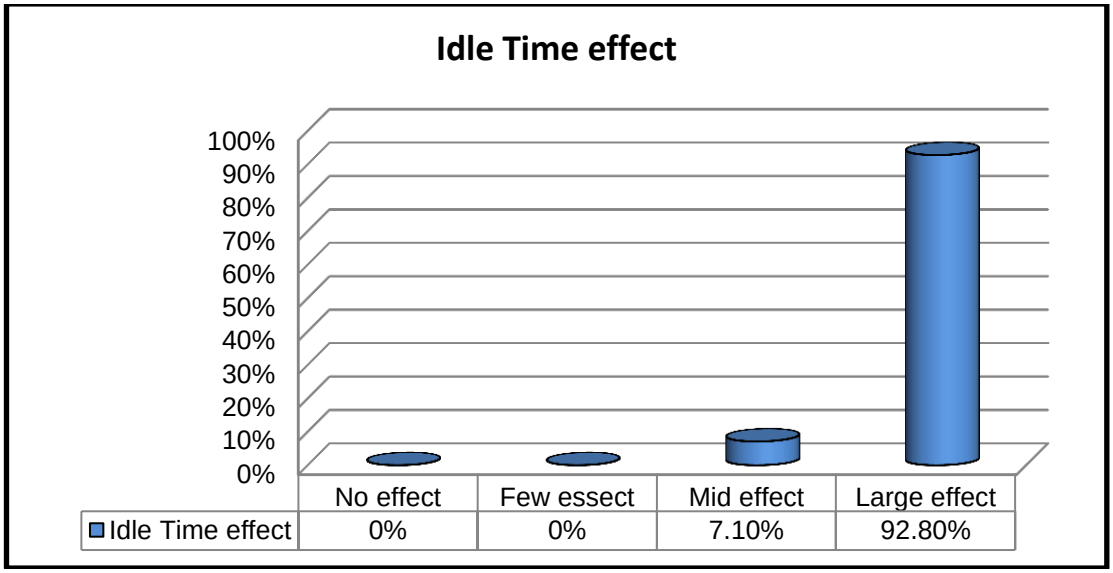


Figure 4.22: The idle time effect according to the participants' responses

2. **Workers and equipment movement in the workplace more than required**
3. **Transportation of materials (movement of materials in site that unnecessary)**

As these two questions nearly could have the same effect both are discussed together. The results revealed that the movement of both workers and equipment more than required influences the project and the respondents had different opinions as 28.5% chose large effect, 14.2% chose mid effect and 57.1% chose few effect. While 7.1% of the participants said that unnecessary movement has mid effect and 92.8% said it has large effect as shown in Figure 4.23. Moreover, one of the interviewees said both unnecessary transportation and movement more than required have a large effect because both wastes time, energy and money whereas another one said it has a small effect since there are more serious issues than this for instance, lack of having those equipment not moving them.

This interviewee claimed the movement problem can be solved from the root by prearrangement for the project so there will not be any need to move anything. Also, Formoso, Isatto, and Hirota (1999) assert that the unnecessary or ineffective movements done by workers during their job, poor arrangements, and insufficient equipment could be reasons for waste. Similarly Banawi (2014) claim more movement of materials increases the chance of waste.

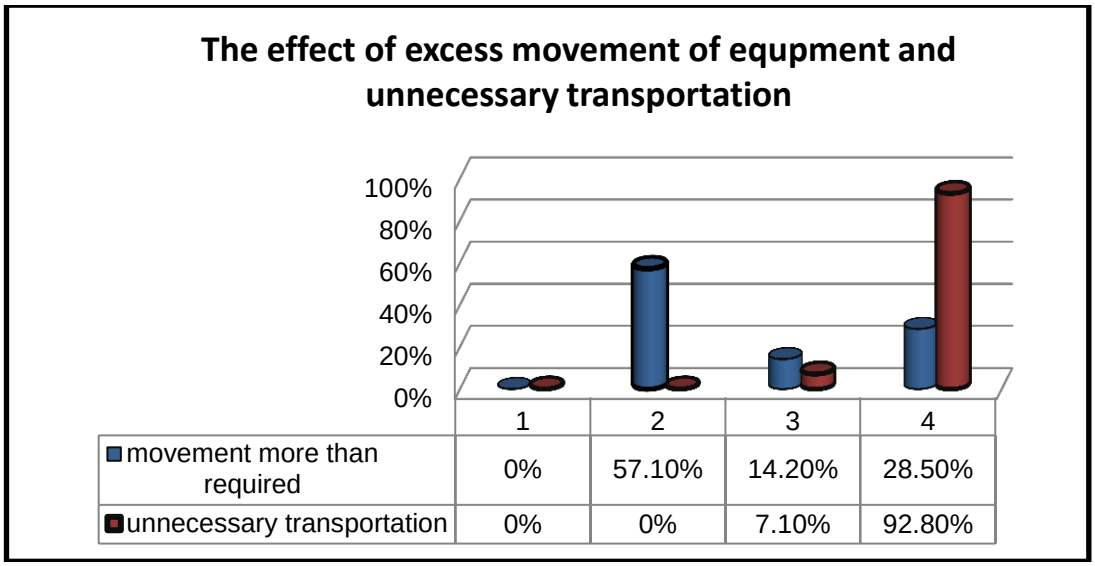


Figure 4.23: The effect of unnecessary and more than required transportation on increasing waste

4. Equipment Presence on Time

As one of the interviewees believed this might be the most fundamental factor which affects any project's success or failure at least in the north of Iraq. He stated sometimes they do not have access to equipment or they have to wait for a long time for the materials to arrive or even sometimes the workers have to perform a very hard job because of lack of machinery and this wastes time because the work will be slower and wastes energy as well. In addition, the questionnaire's participants had the same idea as 100% of them said equipment presence has a large effect as shown in Figure 4.24.

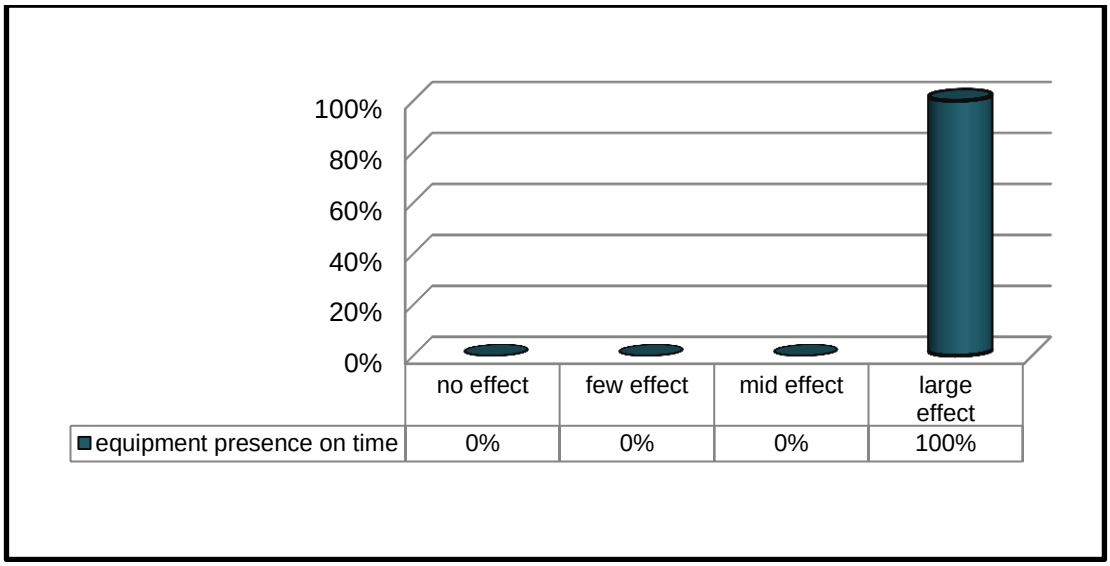


Figure 4.24: The effect of equipment presence on time

5. Correction or Defects

The aim of this question was to find the participants' opinion about the effect of correction or defects. The participants rated its effect differently as 42.8% chose few effect, 39.2% chose mid effect, 17.8% chose large effect but no one said it has no effect as shown in Figure 4.25. Likewise, all the interviewees agreed that it has effect as it wastes time, material and energy but this effect is not very large since it is resolvable.

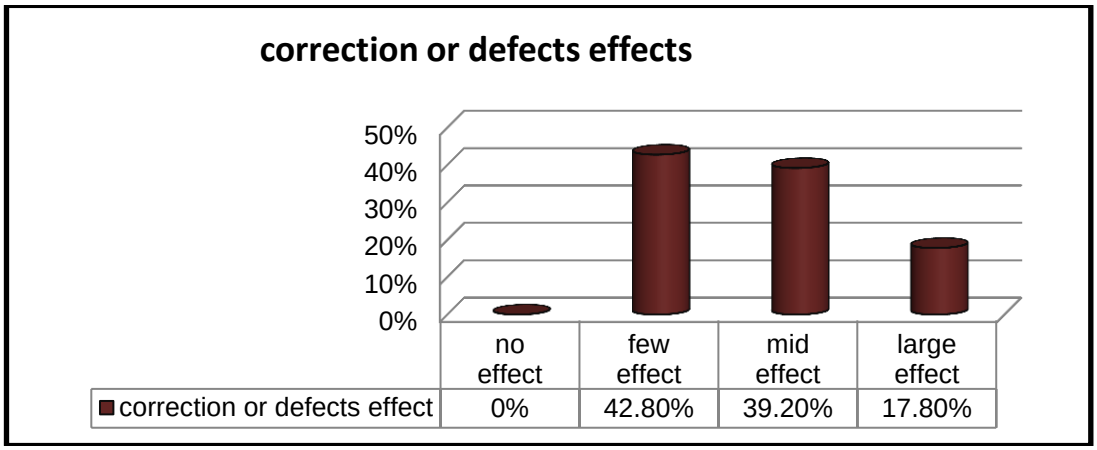


Figure 4.25: The effect of correction or defects

6. **Underutilized Individuals (people creativity, mental and physical abilities)**

The participants acknowledged that it is essential to use people's mental and physical abilities. Neglecting their abilities may causes waste as 10.7% chose mid effect and 89.2% chose large effect as shown in Figure 4.26. Similarly, some of interviewees complained that however it is important but is absent in the most of the construction companies since they just depend on academic qualifications not experience or abilities. Garret and Lee (2010) support this states that inefficient use of these people's mental and physical capabilities results in waste.

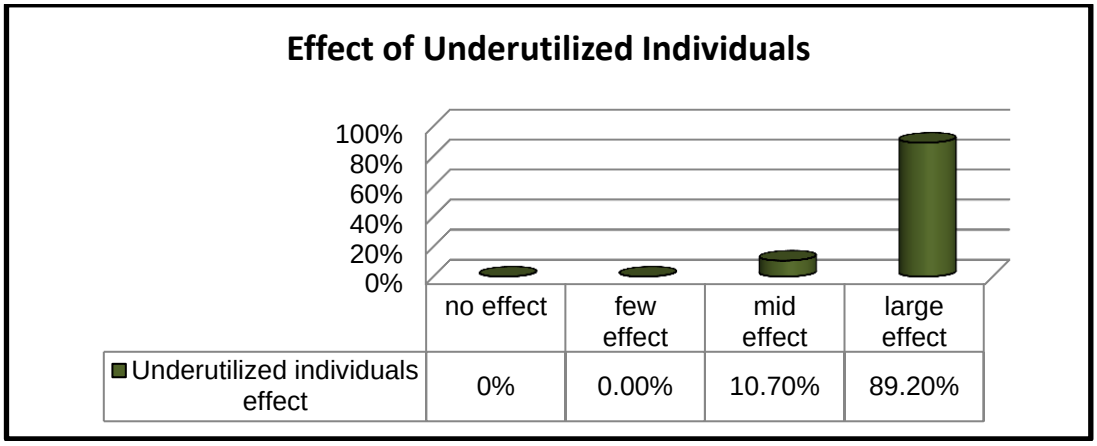


Figure 4.26: The effect of underutilized individuals

7. **Poor Communication between Different Disciplines**

Communication and a good relation among the parties and departments of a project might be important but the respondents had a different idea as 46.4% chose that poor communication has no effect, 25% chose it few effect and only 28.5% chose mid effect as shown in Figure 4.27. Also one of the interviewees said its effect is not so high since it was decided on everything previously. Another interviewee believed that communication among the disciplines is very important because they can discuss

problems, difficulties and requirements and they can solve it together but poor communication leads to making mistakes requiring correction and creates waste.

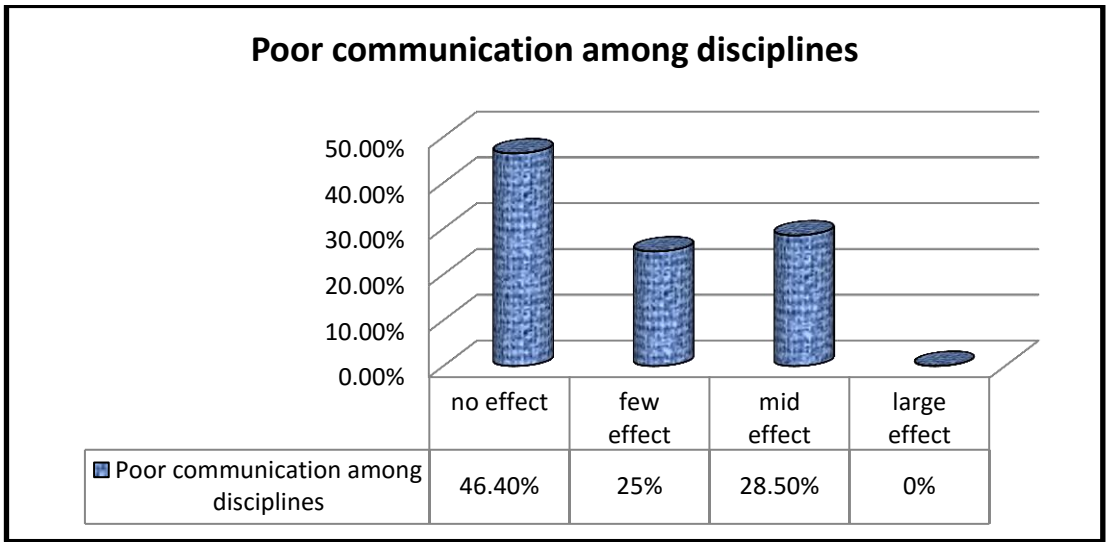


Figure 4.27: The effect of poor communication among disciplines

8. Workers Level of Skill

Most of the participants of the questionnaire accepted that it is essential to the employ skilled workers, as 17.8% chose large effect, 67.8% chose mid effect, only 14.2 chose few effect and no one chose no effect as shown in Figure 4.28. Similarly, all the participants of the interviews stated that utilizing skilled people has a large effect on reducing waste but it is hard to find skilled people for every task. Moreover, sometimes, contractors try to employee a staff with lower salary and this causes waste of time and materials.

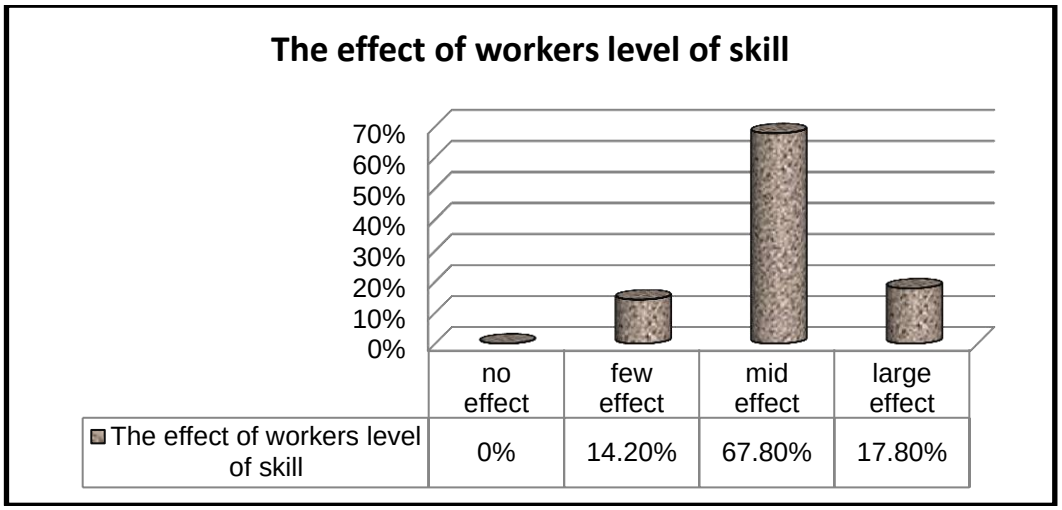


Figure 4.28: The effect of workers level of skill

9. Workplace Safety

This question is based on Salem et al., (2006) claim that safety is one of the lean tools. The responses showed that the participants were aware of the effect of this essential tool as one interviewee said having safety conditions are important because shortage of safety may cause death or delay of the project. Similarly 75% which is one third of the participants of the questionnaire chose large effect and 10.7% chose mid effect while only 14.2% few effects as shown in Figure 4.29. This may relate to the fact that they have not faced this issue as one of the interviewees stated.

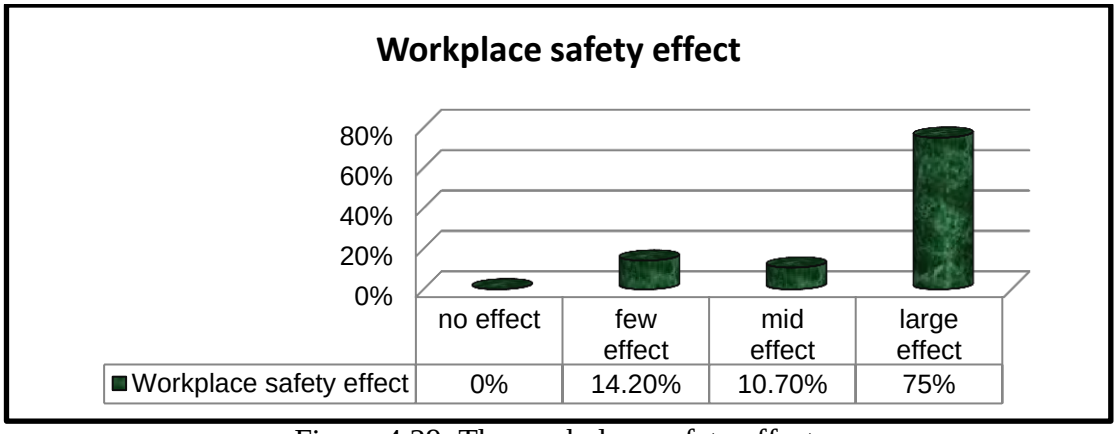


Figure 4.29: The workplace safety effect

10. Poor Management

Ballard (1994) believes that management focuses on control, which avoids bad changes and waste. Likewise, the participants claimed that management is important all of them (100%) believed that poor management has a large effect and the interviewees stated that it is essential to have a good manager and management skills to avoid wasting time, material, energy, abilities and other resources as shown in Figure 4.30.

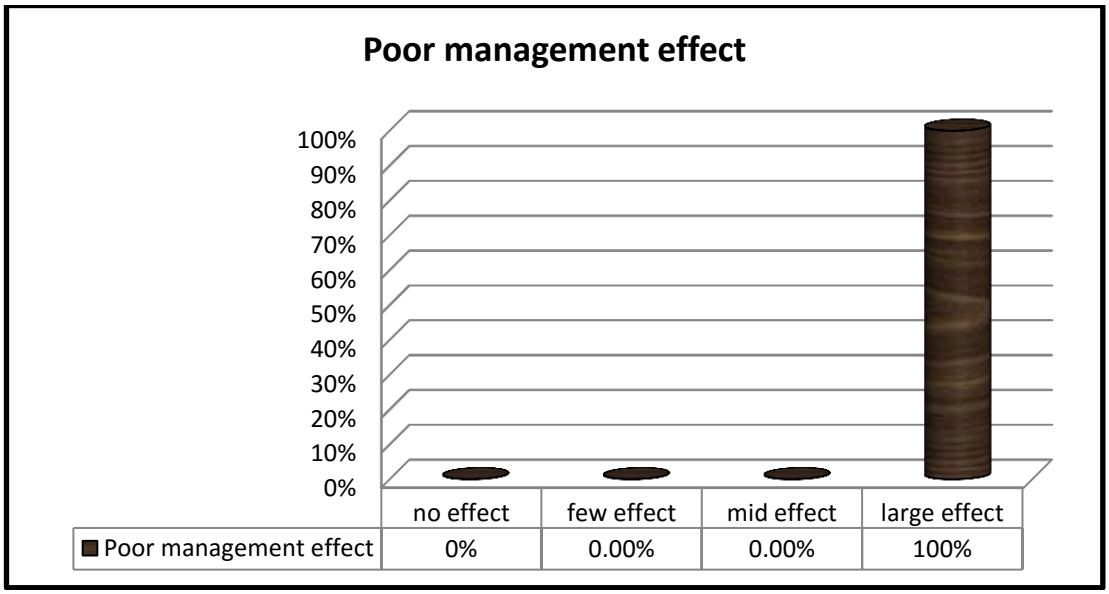


Figure 4.30: The effect of poor management

4.2.3.2 Arrangement in reducing waste in construction industry

1. Government

This question attempts to find out to what extent the government has impact on reducing waste in construction industry. The participants did not choose high effect as one interviewee said mostly the companies is responsible of the projects not government. Only 17.8% chose mid effect but 71.4% chose low effect and 10.7% chose no effect as shown in Figure 4.31.

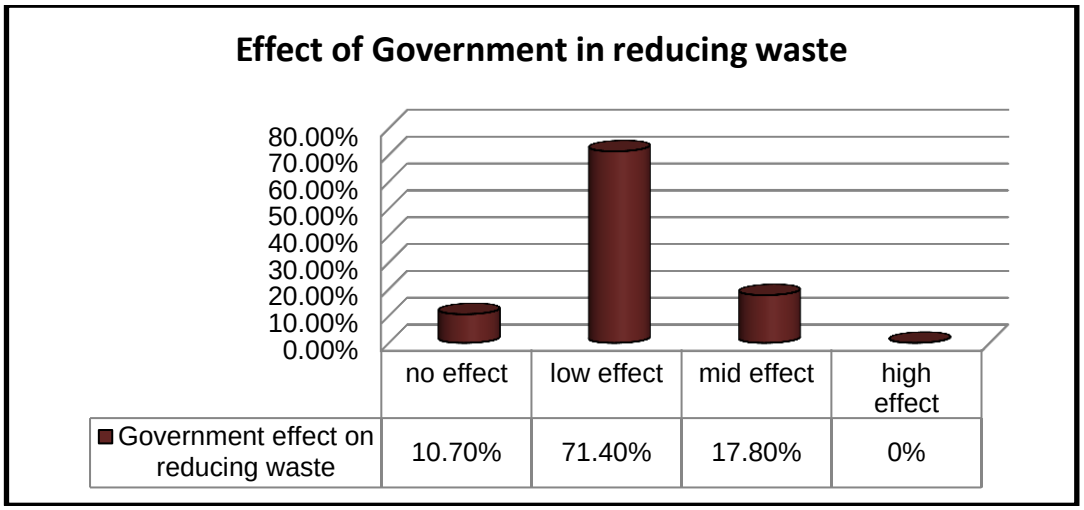


Figure 4.31: The effect of government on reducing waste

2. **New PM paradigm like LC**

3. **Having tools like LPS**

It was decided to discuss these two questions together in order to compare the participants' opinion about new PM and LPS in reducing waste. It seemed that the participants had more positive attitude towards new project management paradigm like LC as no one chose no effect and only 21.4% chose but 60.7% chose mid effect and 17.8% chose high effect as shown in Figure 4.32. An interviewee said a good management system can control waste and reduce it. Jar and Michel, (2009) support this suggesting that a good management system focuses on producing value without generating waste.

On the other hand, in spite of having information about LPS their attitude towards LPS was different as only 3.5% of them it has a high effect and 7.1% chose mid effect whereas 75% chose low effect and 14.2% chose no effect. The reason for having such results might relate to the participants' unsatisfactory experience with LPS as it was mentioned in the second section of this survey. Also an interviewee related it to the difficulties of implementing it in NI as he asserted “what is the

benefit of having schedule and essential plans if we do not have fundamental equipment, material and skilled staff?"

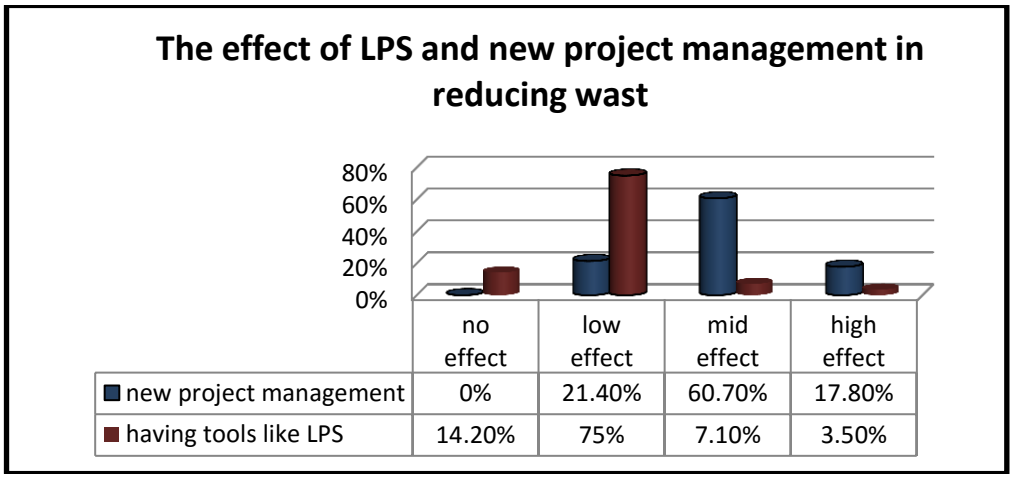


Figure 4.32: The effect of LPS and new management paradigm effect on reducing waste according to the participants' view

4. Expanding the awareness within industry

The responses for this answer showed that the participants are ready to welcome new ideas and modern methods as the interviewees revealed that training courses in all fields are essential not only for engineers but also for contractors and other employees as this helps them to have a better understanding of how to control waste through dealing with the difficulties, utilizing new equipment, performing team working and so on. Also for the questionnaire, 92.8% chose mid effect and 7.1% chose high effect as shown in Figure 4.33.

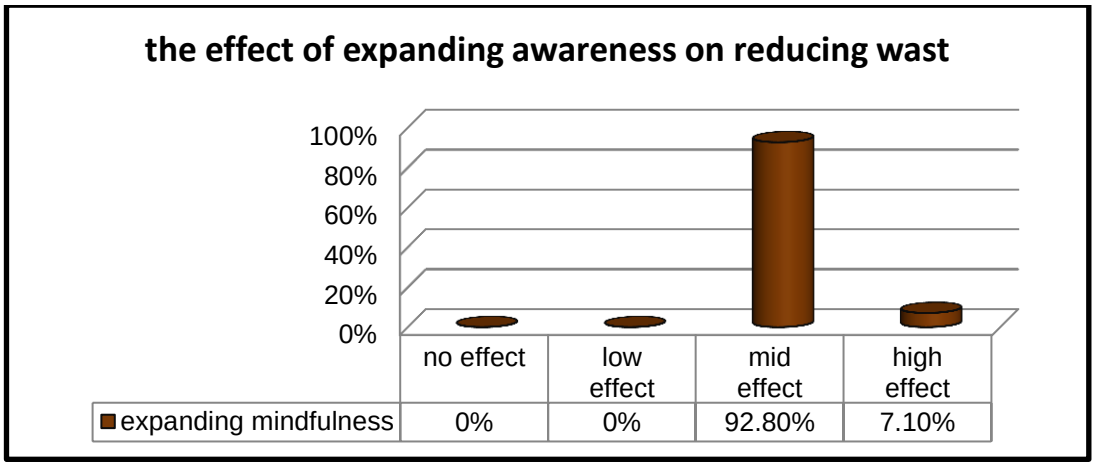


Figure 4.33: The effect of expanding awareness within industry on diminishing waste

5. Ideas sharing between employees

The answers of this question showed that sharing ideas has not such a big impact reducing waste as 71.4% chose no effect and 3.5 chose low effect as shown in Figure 4.34. One of the interviewees claimed that most of the employees are inexperienced and their ideas might be unhelpful also everything has been decided on previously and the employees are not in a position to interfere. On the contrary, another interviewee who was an experienced engineer asserted that he had benefited from peers and other employees' ideas and feedbacks even in a lower rank. Additionally, 10.7% chose mid effect and the other 14.2% chose high effect. Also Ballard (2000) and Howell (1999) claim that consultation with the project performance team can improve the work planning.

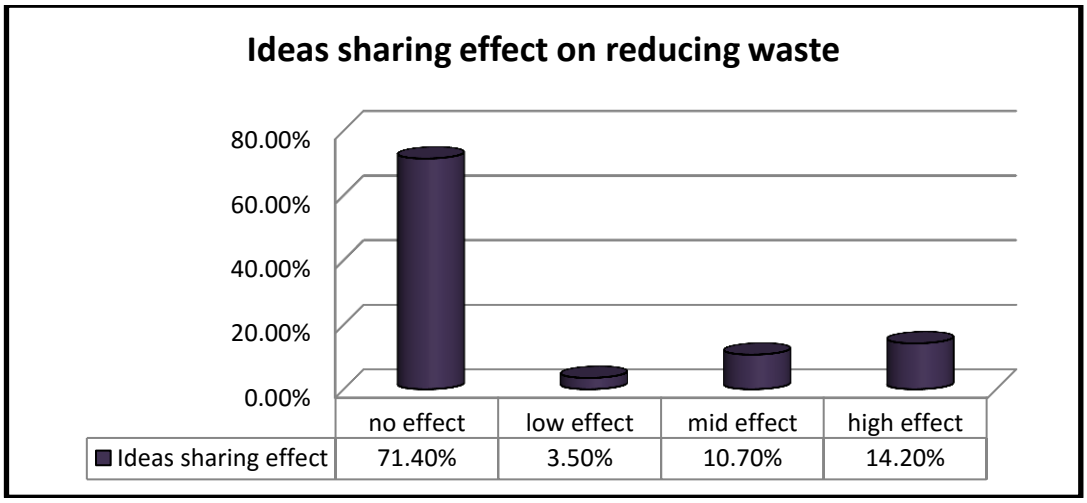


Figure 4.34: The effect of ideas sharing on reducing waste according to the participants

4.2.3.3 Usefulness of WWP and PPC?

Regarding this question 92.8% of the participants said they are only feedback tools and 7.1% of them said they are schedule variance measurement tools. However the participants were given the freedom to choose all applicable answers (i.e. to choose more than one option) but it seemed they chose only one this might be because of they did not have enough experience with LPS. Also the interviewees' answers were variable between these two whereas only one of them said that they are production control tools in the first position then they are root causes analysis tools. Also Ballard, (2000) and Ballard et al., (2007) state that they solve the problems' root causes and prevent their repetition.

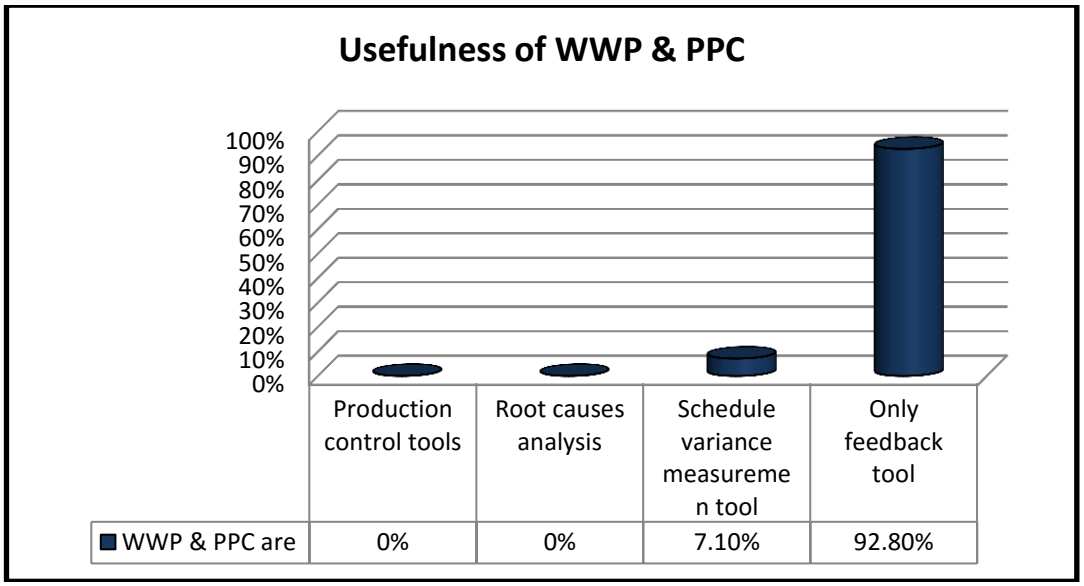


Figure 4.35: WWP and PPC are according to the participants

4.2.3.4 Rating of critical success factors (CSFs) listed below

1. **Top management support**

Regarding this question as participants showed interest of a good management system in their responses to previous questions as they stated that poor management creates wastes and welcomed the idea of new management paradigm like lean construction. Also for this question 100% rated top management support as one of the most effective critical success factors as shown in Figure 4.36. Likewise, the interviewees emphasized that top management has an effective role in the project's success because a good manager arranges all tasks and involves all the employees and provides them with required materials.

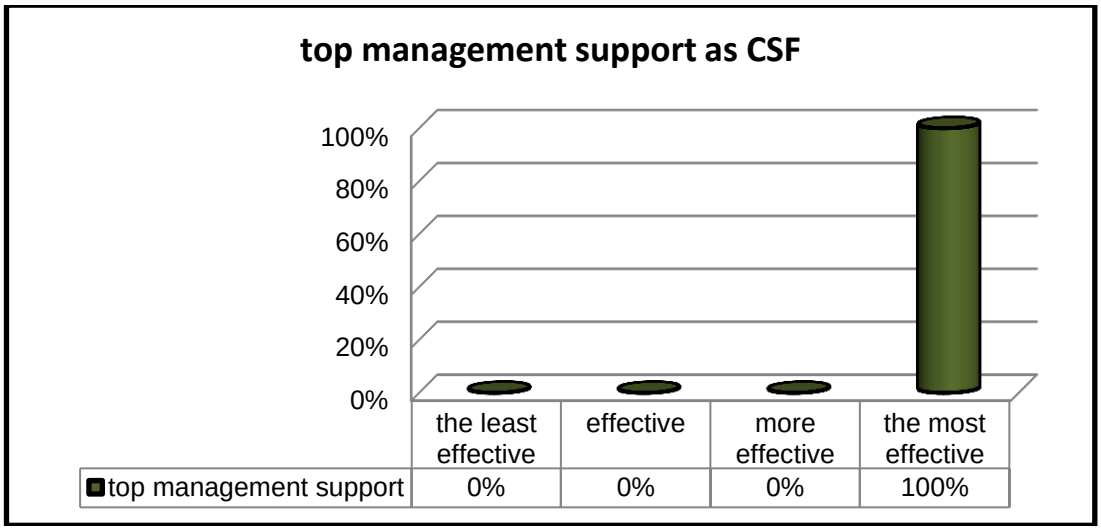


Figure 4.36: Top management support's effect as one of the CSFs

2. Contractual commitment

The responses for this factor were 14.2% stated that it is an effective factor, 21.4% said it is more effective, and the other 64.2% chose it as the most effective factor as shown in Figure 4.37. Also the interviewees believed that it is vital for the supervising engineer to be presence at site in order to perform the job in a better manner, any inadequacy will be solved on time and there is no need for correction of defects in the final stages.

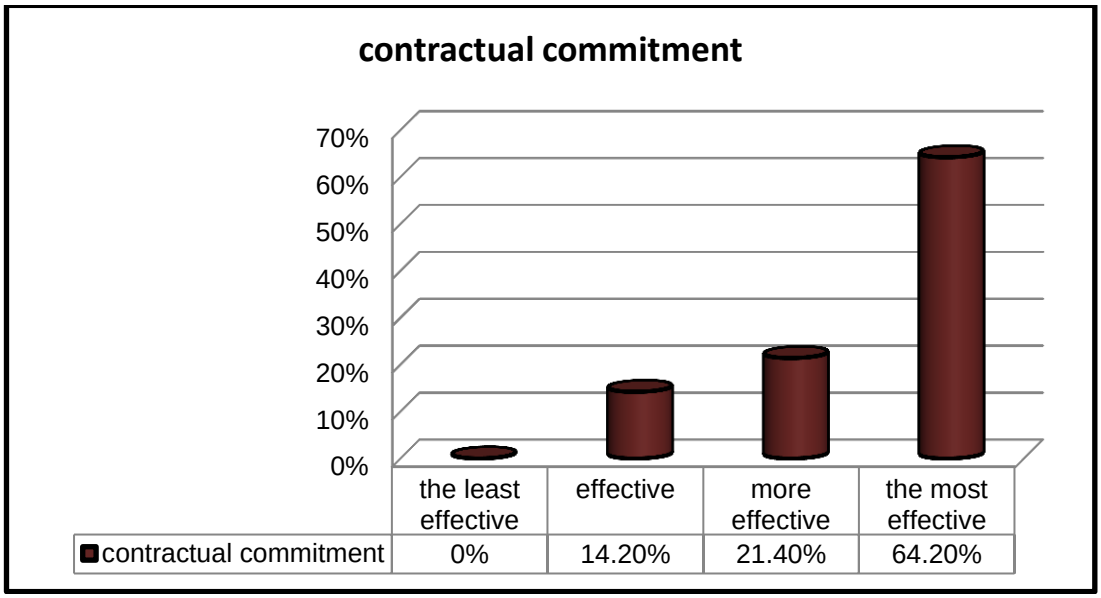


Figure 4.37: The participants' view about contractual commitments

3. Involvement of all participants

This factor seems to be very effective CSF for the projects' achievement as an interviewee said every employee and all who are connected with the project to be involved, in order to every task to be completed on time under the manager and the supervisor's supervision and meet the requirements. Also 71.4% chose it is more effective factor and 28.5% chose the most effect factor as shown in Figure 4.38.

Also according to AIACC (2014) continuous involvement of owner, main designers and constructors from the beginning until the end is very important for the projects' accomplishment. Likewise, involvement of all parties might cause that different tasks to be executed at the same time as Diekmann et al., (2004) claim coordination and assembling the activities to flow in parallel order instead of consecutive order is critical to save time and budget.

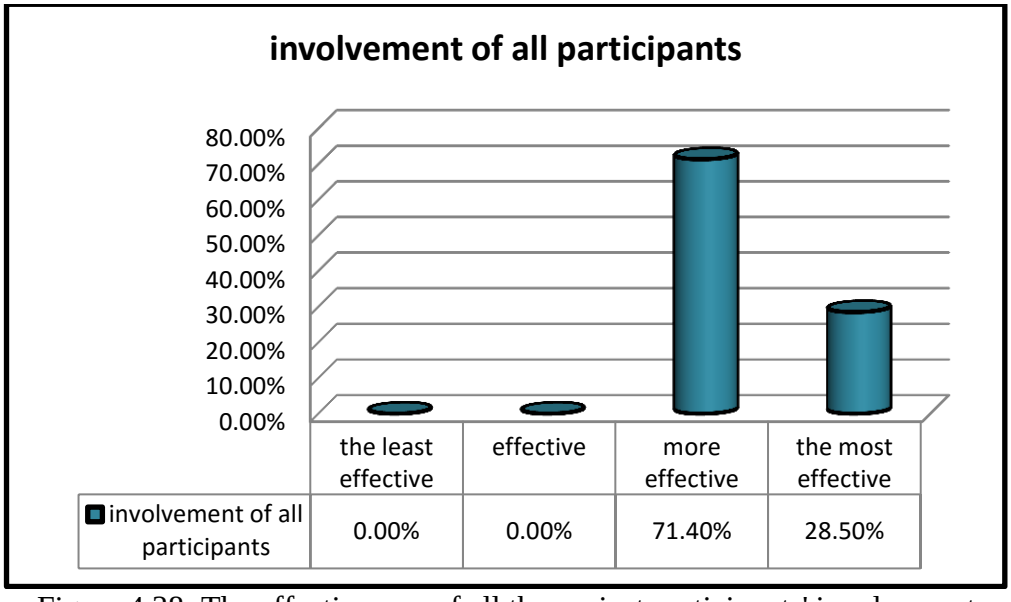


Figure 4.38: The effectiveness of all the project participants' involvement

4. Communication and coordination between parties

57.1% of the participants said it is the least effective, 25% said it is effective and 17.8% said it is more effective as shown in Figure 4.39. The variation of these responses might relate to the fact as one interviewee said when the decision made at the beginning and the designs released, communication is useless if this is to share ideas but if it is to know what is the next step and giving report to the authorities, it is good.

This is quite opposite to Ballard and Howell, (1998) as they claim that face to face discussion improves an implemented strategy, classifies tasks and arranges them. This interviewee also stated that coordination is a very effective and can be regarded as one of the most CSF to accomplish the task on time and encourages team work.

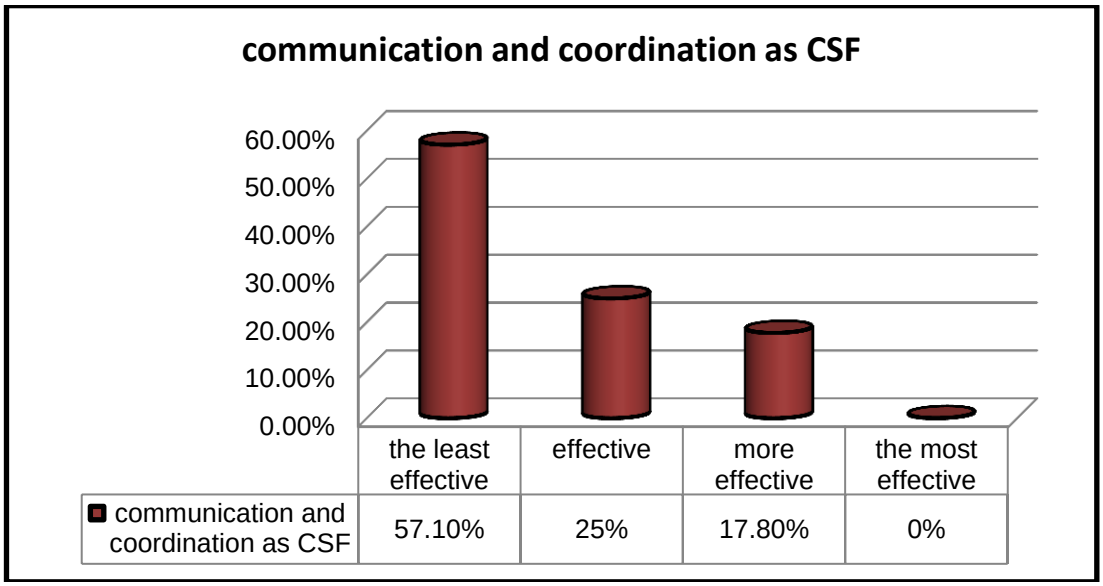


Figure 4.39: Communication and coordination effectiveness as CSF according to questionnaires' respondents

5. **Relationship with subs**

Culture might play an essential role in affecting daily life at that spot of the world as some of the interviewees said most employees and staff members will be chosen on friendship and kin relations bases.

Moreover, they said however this is might affect the project as some of these employed people are unskillful but at the same it has some advantages because all members cooperate with each other, attempt to perform their job as well as they can in order to satisfy each other and do not frustrate their friends or relatives. Similarly, a good relation among employees, managers, engineers, supervisors, contractors, and other parties improves respect and affection as a result everyone performs his task happily. Also the responses to the questionnaire approved this as 35.7% chose more effective and 64.2% chose the most effective as shown in Figure 4.40.

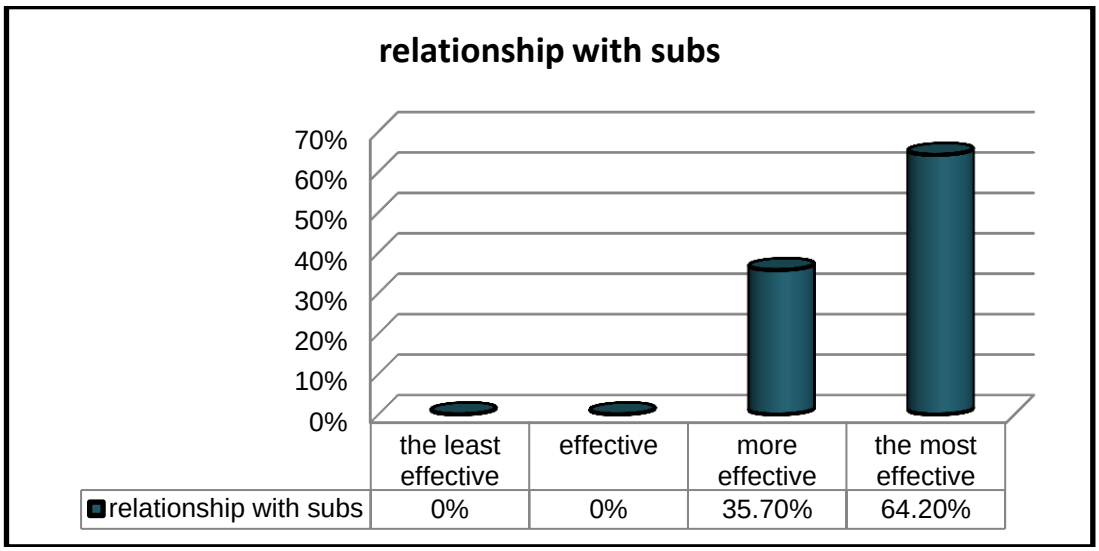


Figure 4.40: The effectiveness of relationship with subs as CSF

4.2.3.5 Difficulties faced by the company during the implementation?

1. **Owner's involvement**

2. Designer/ Engineer's involvement

The answers for these two questions were various as half of the participants said that owner's involvement has low effect, 14.2% said it has mid effect and 35.7% said it has high effect on creating difficulties for the company whereas 60.7% of the participants said that the engineer's involvement has no effect on creating difficulties and 32.1% said it has low effect as shown in Figure 4.41. All interviewees related these variations to the involvement of owner creates difficulties, as the owner may have different enquires from what have done, but all were agreed that in spite of creating difficulties and causing delay, it is good at the same time as all corrections will be done in early stages since if they were left to the final phases, they might require further effort, work, time and money. Diekmann et al, (2004) suggest that the customer's requirements should be determined and analyzed in each production stage. Similarly, the participants asserted that the involvement of the designer or the engineer in all phases is essential to make sure that every task will be executed properly and on time.

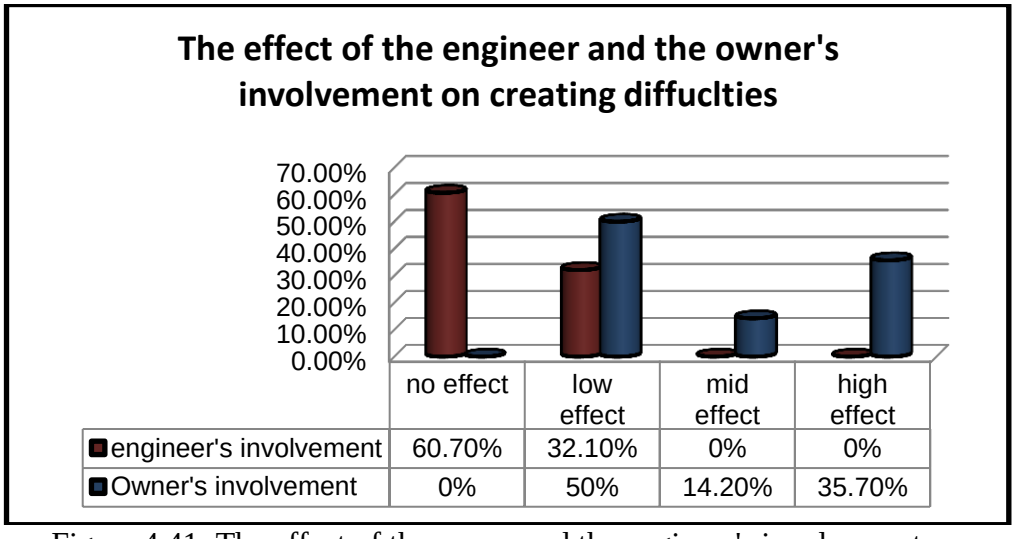


Figure 4.41: The effect of the owner and the engineer's involvement on creating difficulties.

3. **Subcontractor's involvement**
4. **Contractors involvement**

92.8% of the participants chose no effect, 7.1% chose low effect for the subcontractor's involvement and all of them said that the contractor's involvement has no effect on creating difficulties for the company as shown in Figure 4.42.

One interviewee stated that the involvement of both the contractor and the subcontractor is essential for the company's certainty that the project will be under control, the contractor can evaluate the subcontractor and can decide to hire that person for future tasks and the workers perform their job without delay or negligence. It can be said that the results for these two questions assemble with the finding of the study which conducted in Chile and developed a method which was useful in solving many problems and assisted subcontractors to monitor the labors' performance on site. Moreover, it directs the main contractor to get to a right decision in order to choose appropriate subcontractors for the future tasks Maturana et al. (2007).

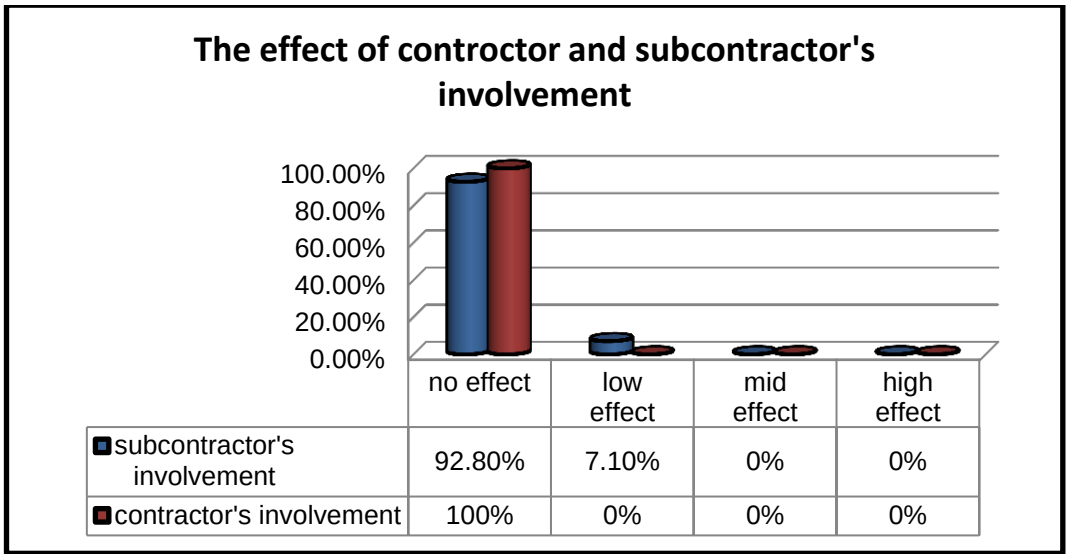


Figure 4.42: The effect of contractor and subcontractor's involvement on creating difficulties

5. Educate participants with LPS

All the interviewees are interested of the idea of educating the participants with LPS and said it has no impact on creating difficulties but at the same time some of them were concerned about other obstacles in front of implementing this system as they stated 'educating people with new methods is essential but in the NI it is more important to attempt to provide modern machinery, material and improving the road condition because having information, plan, design and skilled staff are useless without having required material'.

Likewise, 78.5% of the survey's participants chose it has no effect on making difficulties for the companies and 21.4% chose it has low effect as shown in Fig.4.43.

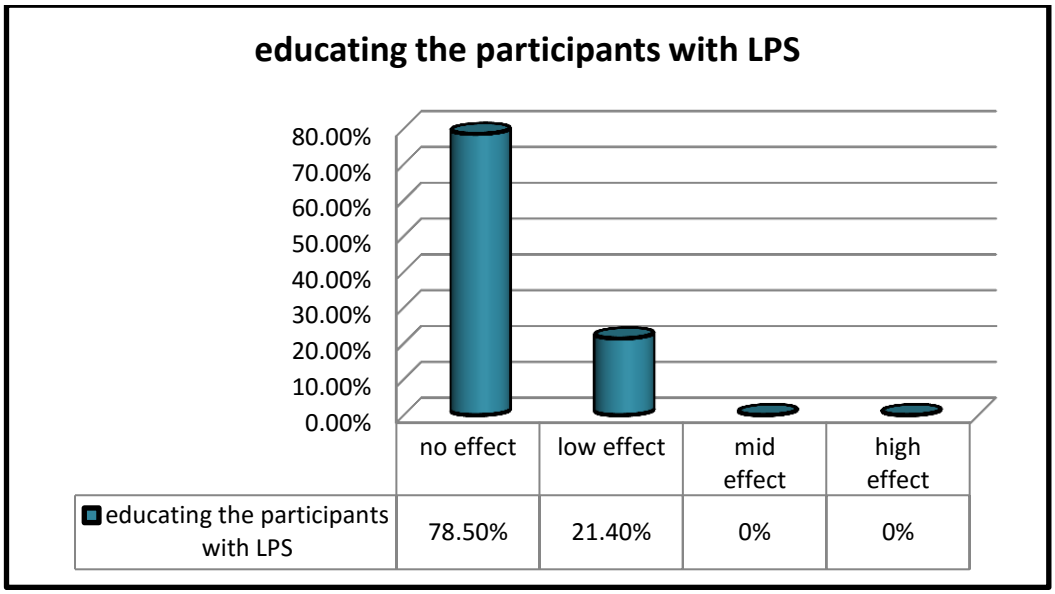


Figure 4.43: The effect of educating people with LPS on creating difficulties for the companies

4.2.3.6 Implementation challenges at organizational level Instructions:

1. **There is a strong leadership in my organization for implementing LPS.**
2. **Management in my organization is committed to the implementation and use of LPS.**

To answer these questions, the participants were not satisfied about the leadership for implementation of LPS in their organizations as 78.5% of the participants chose disagree and the other 21.4% of them chose agree on the other hand 100% of them chose disagree because all of them believed that the management is not committed to implement LPS as shown in Fig.4.44.

The interviewees related this to the fact that there might be a strong willingness among the managers to implement LPS and even they might have tried it but the difficulties that they face such as lack of machinery or material flow could be the reason to regret their decisions.

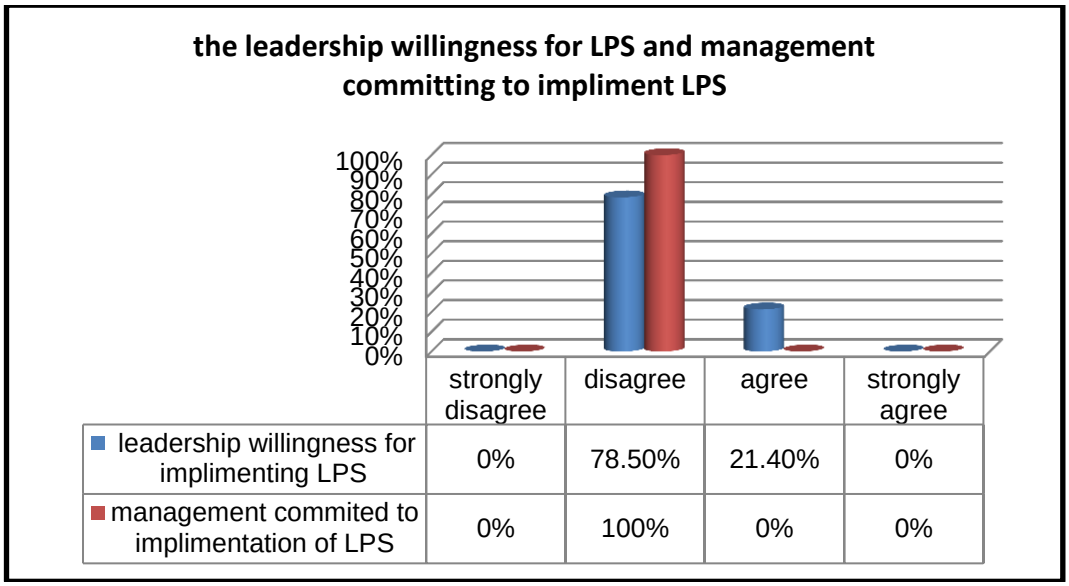


Figure 4.44: The participants' view about the leadership for implementing LPS and management committing to implement LPS.

3. **In my organization people are reluctant to implement and use LPS for planning and control purposes.**
4. **In my organization people are unwilling to change, when new systems are introduced.**

The responses showed that engineers, contractors and constructors are willing to change but they are hesitant as 17.8% were strongly agreed, 71.4 were agreed that people are reluctant to implement LPS and only 10.1% disagreed as an interviewee claimed that not all people are reluctant as some loves trying new methods but the organizations do not support them even they prevent them as shown in Figure 4.45.

Also 71.4% of those participants disagreed that they are unwilling to change when new systems are introduced and the other 14.2% of them agreed and the interviewees admitted that most of the people who work in construction industry have a great tendency to change and apply new methods but they are hesitant as access to

required material and machinery is limited and they are not allowed to follow any methods or plans as the companies impose their methods.

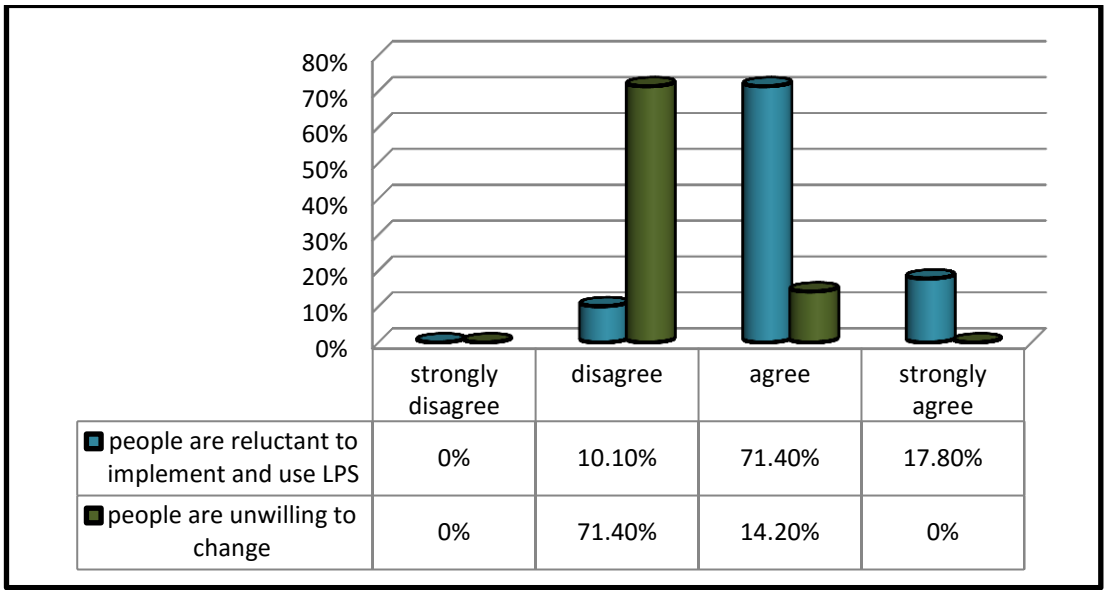


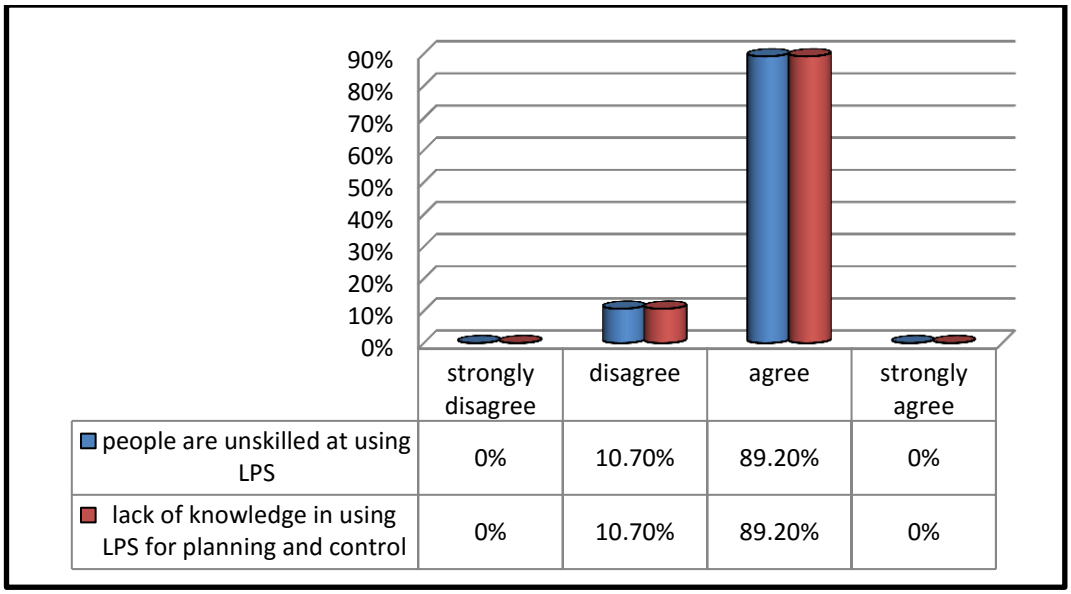
Figure 4.45: The participants' view about people who are unwilling to change when new systems are introduced and those are reluctant to implement LPS

5. **In my organization people are not skilled at using LPS.**
6. **In my organization people do not have enough knowledge in using LPS for planning and control purposes.**

The answers of these two questions were the same as 10.7% disagreed and 89.2% agreed that people in their organizations are unskilled at using LPS and do not have enough knowledge in using LPS for planning and control purposes as shown in Figure 4.46.

Additionally, the interview participants said that there are some skilled people who have rich knowledge and experience in most of the companies and organizations as they required their knowledge while they were working or studying abroad or

working with foreign companies. Also there are some people who have some knowledge but it is not enough to take the responsibility and practice it and the companies do not support them to improve their skills and information.



	strongly disagree	disagree	agree	strongly agree
people are unskilled at using LPS	0%	10.70%	89.20%	0%
lack of knowledge in using LPS for planning and control	0%	10.70%	89.20%	0%

Figure 4.46: The participants' view about unskilled people and lack of knowledge in using LPS for planning and control in their organizations.

7. **In my organization people find it hard to use the LPS.**
8. **My organization faces external conflicts (example: lack of client support or subcontractor support) and challenges in implementing and using LPS.**

The responses of these two questions were analyzed together as the answers were correlated to some extends. 100% of the candidates agreed that they find it hard to use the LPS in their organizations. Also 14.2% of the nominees chose disagree and 85.7% chose agree that they face challenges and conflicts in implementing LPS as shown in Figure 4.47. As one interviewee complained about this issue and stated that everyone should follow the company's rules and methods no one cares how much

you know but they want you to do your job.

Another candidate said everyone wants a perfect job but they do not allow the staff members to express their ideas or support them. In addition another interviewee claimed that sometimes the responsible person or the client do not care about how the staff perform the job the most important thing is the job to be perfect at the end but at the same time they are uncooperative and do not provide the machinery or the required material on time. According to the above responses it can be said that still the traditional methods are followed in the NI as they focus on the result more than the process.

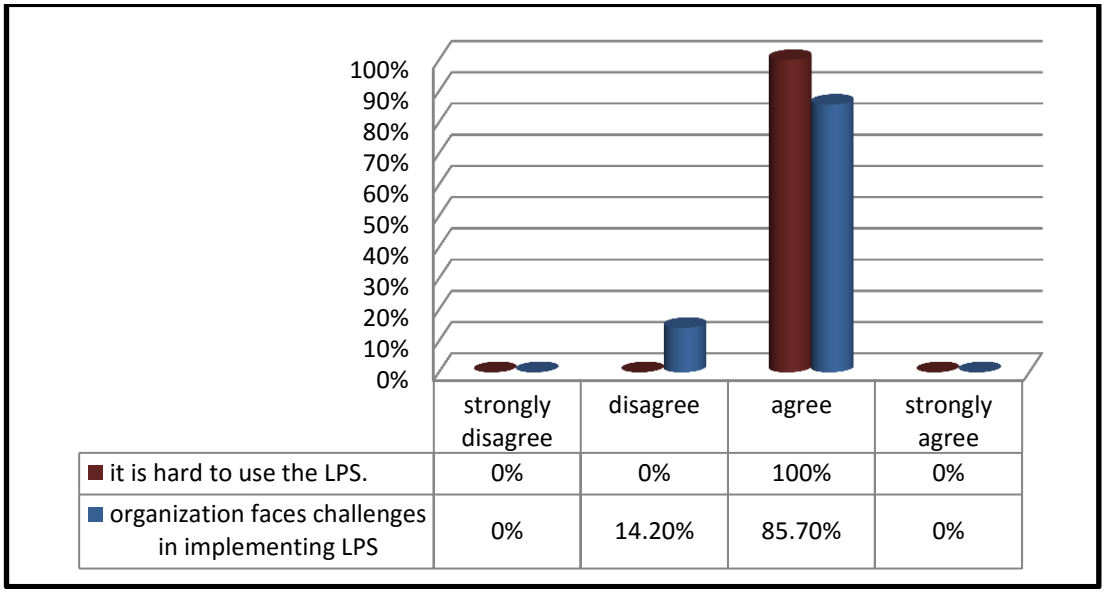


Figure 4.47: Candidates' opinion about the hardness of implementing LPS and external challenges in implementing it.

9. In my organization people find it difficult to collaborate with the teams from other organizations during the WWP meetings

Regarding this question the participants had more negative responses as most of

them agreed that they find it difficult to collaborate with the teams from other organizations so 92.8% chose agree and 7.1 chose disagree as shown in Figure 4.48. One of the interviewees said it is difficult to help each other and share ideas because there is no formal weekly work plan meeting so the team leaders and members see each other from time to time or during their working hours discus their thoughts while the other interviewees admitted that no one desires to help the others, everyone wants to keep the best ideas as a secret and perform the best job to be famous and attain the next project or get a better job with a better payment with the well-known companies in the country.

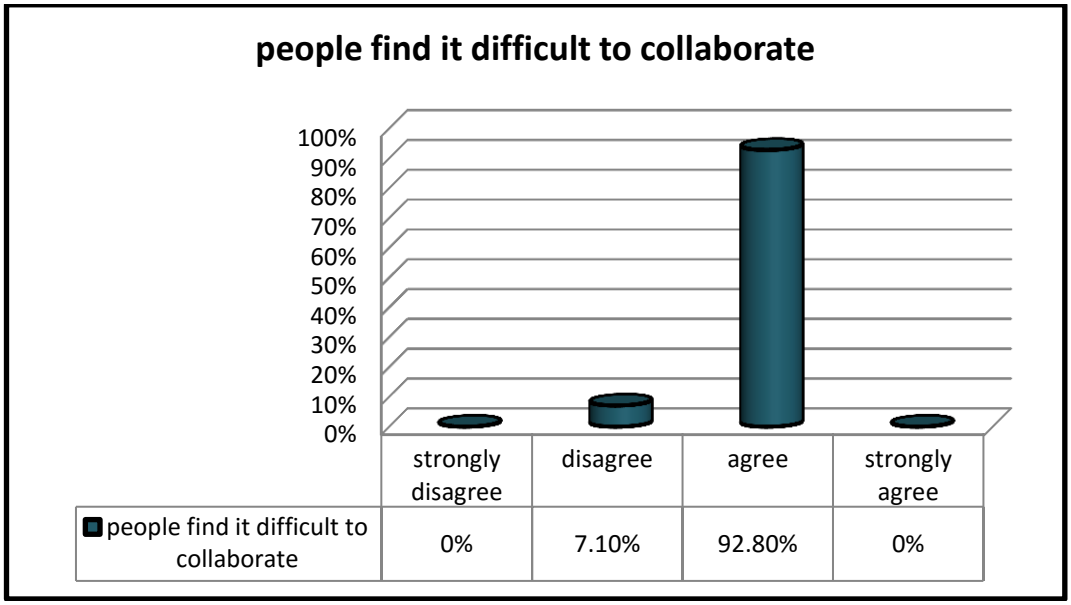


Figure 4.48: The participants' view about the teams and the team members' collaboration

4.2.3.7 Implementation of LPS in the Future Projects?

All the participants who completed the survey until the end had information about LPS only 7.1% of them had no experience as it was mentioned in section two of this questionnaire. Almost all of them interested of implementing this method in the future as only 4% of them said, 21 said maybe as one interviewee said "I am not sure

about its success because it might take a long time for the employees and the companies to get used to it". The other 75% said this method should be implemented in the future projects as shown in Figure 4.49.

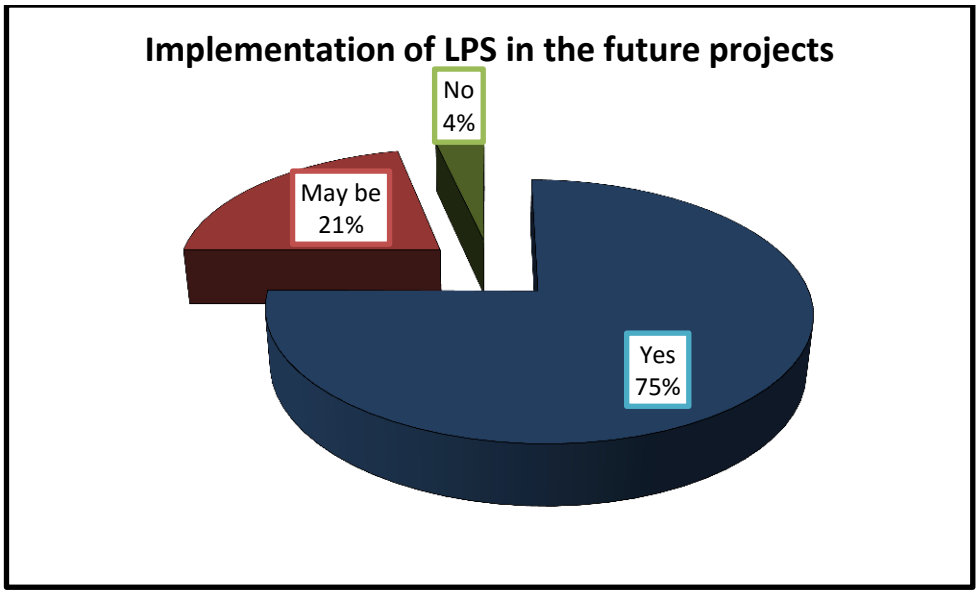


Figure 4.49: The participants' opinion regarding the implementation of LPS in the future

4.2.3.8 Summary of the results regarding LC using the LPS and other factors in solving construction problems

To sum up, it was found that the section revealed that in spite of the participants' limited experience about LC and LPS still they were aware of waste causes, solutions, CSF difficulties confronting the projects and implementation of new ideas. Additionally the participants would like to implement new methods and improve their knowledge but they face many difficulties.

4.4 Summary of the chapter

In this chapter the outcomes and the findings of the practical study of this investigation were calculated and debated. Also the case study which was conducted by the researcher was illustrated. This case study was in four stages; (i) LPS training,

(ii) PPS sessions, (iii) Development of 6 WLAP and WWP, and (iv) LPS implementation assessment process supported by interviews and questionnaire. The results exposed the existence of a connection among the findings of some of the researchers were lead in various spots of the world and the NI. Moreover, to some extent the theories were encountered over the defendants' responses. For instance, the respondents' information about LC using the LPS was very restricted and they are interested of learning it and implementing it in the future projects. Furthermore, the nominees revealed that many other factors affecting waste and implementing LPS in the NI. This might relate to the political and cultural issues. Similarly, the results provided evidences of advantages of planning process.

4.5 Implementing of Lean Construction

Application of Lean saves time and money and decreases the negative environmental effect and it is required for both today and future needs as it. Despite the hardness of implementation, it is supposed to be mandatory in the future. Owners and contracting firms are the most influential sectors on embracing of Lean while design establishments, consultants, educational institutes, professional bodies and governments come in the second place. The following are the basic step which is involved in the development of a model to be implementable in NI. The Flow chart of Last planner system is shown in the figure 4.50.

The LPS was only implemented half-way through the projects. The research plan was to undertake the implementation process in four phases with an evaluation being made at the end of each phase. This incremental implementation is believed to gradually stabilize the elements of LPS, minimize resistance to change, and have the additional advantage of providing an opportunity to evaluate each phase and take the

lessons learned to the next one. Figure 4.50 shows the implementation strategy of LPS in the studied cases.

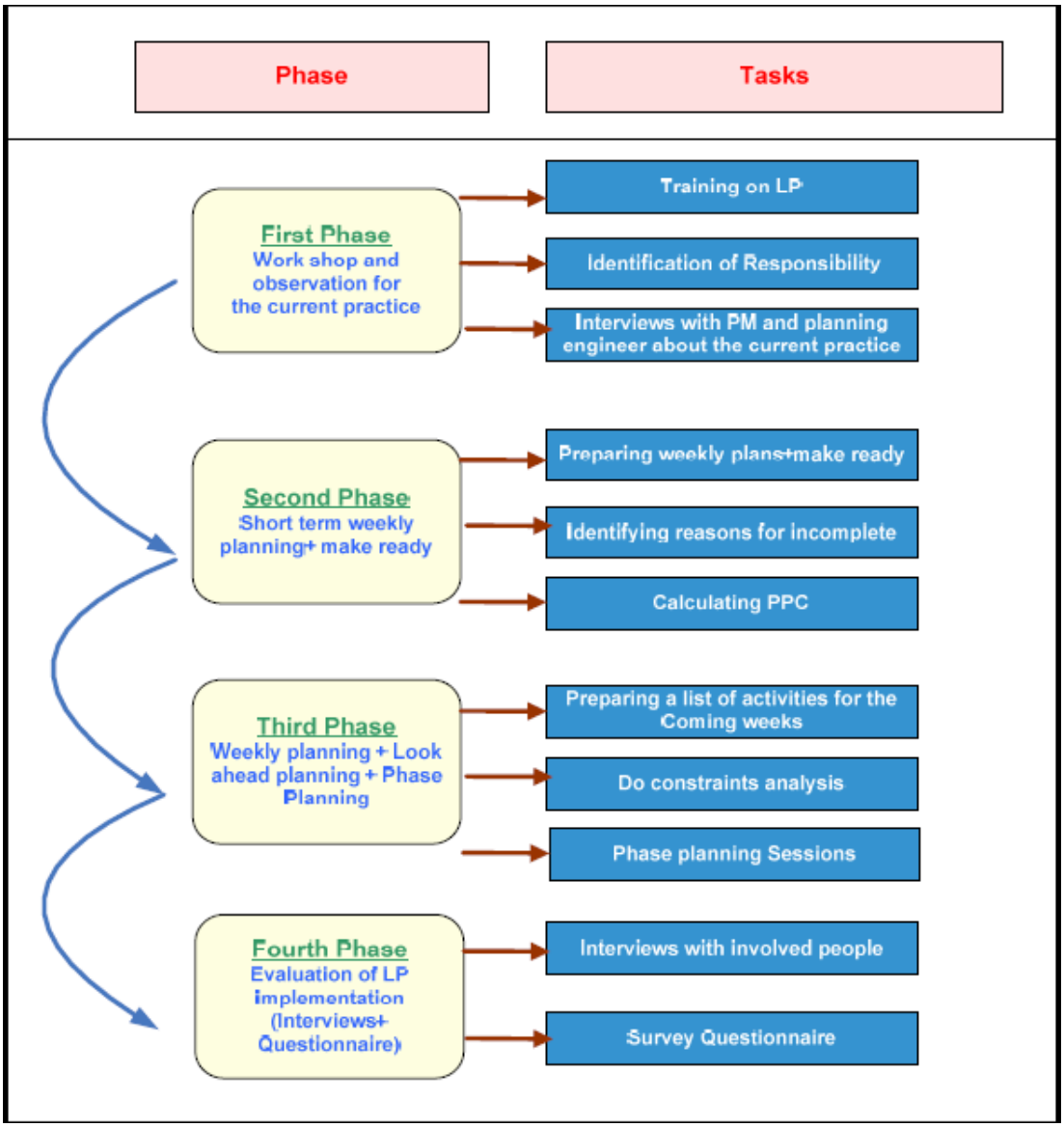


Figure 4.50: Model Development of Last Planner System

Chapter 5

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

The purpose of this research was to investigate the economic and environmental benefits of implementing of LC using LPS as a tool in the construction industry as well as the challenges facing its implementation and recommendation that observed during this research.

The objective of this study was to implement and evaluate the LPS on a given project. This study has provided new insights with respect to the issues surrounding the implementation of a new concept on an ongoing project and the issues related to implementing the LPS. The following conclusions can be derived from this thesis:

1. The LPS technique proved that it could enhance planning aspects of construction management practice and bring numerous advantages. Comparison between PPC ratios computed indicated the successful implementation of the LPS in the project. Moreover the successful implementation of the LPS was supported by the fact that the project management team was able to recover construction activities for structure.
2. Half of the survey participants admitted that the LPS increase workload sometimes. However, the LPS were a new concept for majority of the respondents.
3. Although, there were some obstacles preventing the achievement of full

potentials of LPS, the implementation process in the project was successful, as confirmed by the results and outcomes of the survey questionnaire.

4. Survey results identified level of involvement from subcontracting firms as one of the main barriers hindering the LPS implementation. Majority of general contractor's and owner's representatives proposed getting contractual commitment from the subcontractors.

5.2 Challenges

It seems that there is a shortage in Lean professionals, plus a lack of legal framework and contract system that enable collaboration between all parties. The awareness of Lean is still not common within the industry. In addition to the huge initial investment in IT infrastructure required for implementing LPS.

5.3 Suggestions

Awareness should be increased among the industry professionals specially owners and contracting firms about the importance of embracing new concepts within the industry to minimize the negative environmental impacts and maximize the economic benefits.

In order to enable collaboration between all parties, a new form of legal framework and contracts should be developed. Educational institutes should provide programs about new construction management concepts that help to prepare a new generation of professionals who are ready to implement these concepts on the ground.

5.4 Recommendations for further research

This study recognizes that further research is required in order to better identify the benefits and challenges of implementing Lean concepts. The following areas are recommended for more research:

1. Investigation of Lean challenges in each country aside.

2. Further researches should be required to investigate in depth the role of educational institutes and professional bodies in preparing Lean professionals.
3. Research needed to be carried out on projects owners (real-estate developers, investors and governments) the results may be helpful in identifying the key challenges against Lean implementations.
4. Development of a training program, which will train the future last planners (schedulers, superintendents and foremen) and communicate the goals to all parties in the construction project. Traditionally, the project participants resist the change process unless they believe it is both useful and possible, demonstrated through a proper training program.
5. Customize the existing valuable steps of LPS according to the future projects/organizations and eliminate wasteful steps.
6. Future studies on LPS can incorporate project control system such as earned value method along with weekly work plans to improve decision making process at operational level.
7. A similar study can be tested for different construction projects, i.e., infrastructure, communications, heavy engineering, transportation, civil, healthcare, government, etc.

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APPENDIXES

Appendix A: Introduction Letter

Hello,

This voluntary questionnaire is part of my master thesis research about implementing of Lean construction (LC) using Last Planner System (LPS) in the construction industry require for MSc. Degree. The purpose of this study is to examine the causes of waste in construction industry and what should be done to reduce it, has LPS implemented in NI? And should it be executed in the future projects?

This questionnaire takes only 10 Minutes to complete. Please fell confident during filling this questionnaire as it confidential and it used for research purpose only. The survey contains three sections (1, 2 & 3). Your completion of this survey is voluntary.

By participation in this survey, you decide to include your responses as a part of my investigation. Please, answer the questions as an honestly as possible.

Thank you in advance for your time and support, we do appreciate your time.

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Appendix B: Survey Questions

Questionnaire Form

Survey Questions Section 1 (General Information)

* Required

1. **Ginder** *
   Mark only one oval.
   - ◯ Male
   - ◯ Female

2. **Age** *
   Mark only one oval.
   - ◯ 18-24
   - ◯ 25-34
   - ◯ 35-44
   - ◯ 45 Or More

3. **Where do you work?** *
   Mark only one oval.
   - ◯ Private Sector
   - ◯ Stat Organization

4. **Your Education Level?** *
   Mark only one oval.
   - ◯ PHd
   - ◯ MSc
   - ◯ BSc
   - ◯ Other: _____

5. **Your position within industry?** *
   Mark only one oval.
   - ◯ Contructor
   - ◯ Subcontractor
   - ◯ Site Engineer
   - ◯ Project Manager
   - ◯ Other: _____

6. **Which organization you are working for?** *
Mark only one oval.

- ◯ Contracting
- ◯ Consultation
- ◯ Education Institutes
- ◯ Other: _____

7. **Experience within Construction industry?** *
Mark only one oval.

- ◯ Less than 1 year
- ◯ 1-5 years
- ◯ 5-10 years
- ◯ 10-20 years
- ◯ More than 20 years

Questionnaire Form

Survey Questions Section 2

* Required

1. **Do you have experience with Lean construction?** *
If YES ,please indicate in years.
Check all that apply.

- ☐ NO
- ☐ Less than 1 Year
- ☐ 1-3 Years
- ☐ More than 3 Years

2. **Do you have any information about Last Planer System?** *
Mark only one oval.

- ◯ Yes
- ◯ NO *After the last question in this section, stop filling out this form.*

3. **The results achieved, are they satisfactory or not?** *
If yes, please rate on scale of 1 to 4 .
Mark only one oval.

	1	2	3	4	
is the least	◯	◯	◯	◯	is the most satisfactory

Questionnaire Form

Survey Questions Section 3

* Required

1. **What are the effects of the following on the Lean construction?** *

Mark only one oval per row.

	Has no effect	Few effect	Mid effect	Large effect
Idle time (Time between activities)				
Workers and equipment movement in the workplace more than required				
Transportation of materials (movement of materials in site that unnecessary) Transportation of materials (movement of materials in site that unnecessary)				
Equipment presence on time				
Correction or defects (when the final product doesn't meet the quality)				
Underutilized individuals (peoples creativity,mental and physical abilities)				
Poor communication between different disciplines				
workers level of skill				
Workplaces safety				
Poor management				

2. **Arrangement in diminishing waste in construction industry?** *

Mark only one oval per row.

	No effect	Low	Mid	High
Government				
New project management paradigm like lean construction				
Having tools like LPS				
Expanding the mindfulness within the industry				
Ideas sharing between employees				

3. **How Weekly Work Plan (WWP) and Percent Plan Complete (PPC) in Last Planner System are useful to you?** *

Check all that apply.

- [ ] Production control tool
- [ ] Root cause analysis tool
- [ ] Schedule variance measurement tool
- [ ] Only feedback tool

4. **Please rate critical success factors (CSFs) that affect by using this method (LPS) as listed below** *

considering 1 is least and 4 is most
Mark only one oval per row.

	1	2	3	4
Top management support	◯	◯	◯	◯
Contractual Commitment	◯	◯	◯	◯
Involvement of all participants	◯	◯	◯	◯
Communication and coordination between parties	◯	◯	◯	◯
Relationship with Subs	◯	◯	◯	◯

5. **What were the main difficulties faced by the company during the implementation of Last Planner System?** *

considering 1 is least and 4 is most
Mark only one oval per row.

	1	2	3	4
Owner's involvement	◯	◯	◯	◯
Designer/Engineer's involvement	◯	◯	◯	◯
Subcontractor's involvement	◯	◯	◯	◯
Contractor's involvement	◯	◯	◯	◯
Educate participants with LPS	◯	◯	◯	◯

6. **Implementation challenges at organizational level Instructions: Below you will find a series of statements about your experiences with implementation and use of Last Planner System (LPS) - on all the projects that you have done using LPS. Some items may sound similar, but they address slightly different issues. Please respond to all items. Indicate your degree of agreement with each statement by placing the appropriate number in the box next to each item.** *

Please use the following grid: 1-Strongly Disagree 2- Disagree 3-Agree 4-Strongly Agree
Mark only one oval per row.

	Strongly Disagree	Disagree	Agree	Strongly Agree
There is a strong leadership in my organization for implementing LPS.	◯	◯	◯	◯
Management in my organization is committed to the implementation and use of LPS.	◯	◯	◯	◯
In my organization people are reluctant to implement and use LPS for planning and control purposes.	◯	◯	◯	◯
In my organization people are unwilling to change, when new systems are introduced.	◯	◯	◯	◯
In my organization people are not skilled at using LPS.	◯	◯	◯	◯
In my organization people do not have enough knowledge in using LPS for planning and control purposes.	◯	◯	◯	◯
In my organization people find it hard to use the LPS.	◯	◯	◯	◯
In my organization people find it difficult to collaborate with the teams from other organizations during the weekly-work-plan meetings.	◯	◯	◯	◯
My organization faces external conflicts (example: lack of client support or subcontractor support) and challenges in implementing and using LPS.	◯	◯	◯	◯

7. **Do you think that this method (LPS) should be used in the future projects?** *

Mark only one oval.

- ◯ YES
- ◯ MAY BE
- ◯ NO