Improving construction processes in Nigeria using the Last Planner System

IMPROVING CONSTRUCTION PROCESSES IN NIGERIA USING THE LAST PLANNER® SYSTEM

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A thesis submitted in partial fulfilment of the
requirements of the University of Wolverhampton
for the degree of Doctor of Philosophy

October 2014

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1/12/2014

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ABSTRACT

This thesis describes a research investigation into the implementation of the Last Planner System (LPS) in Nigeria, to improve construction processes within the Nigerian construction industry.

LPS is known to be the most developed practical use of Lean Construction. It focuses on minimising the negative impacts of variability, uncertainties, buffers, making projects more predictable, creating reliable work plans and convalescing collaborative planning.

However, the Nigerian construction industry is associated with a number of challenges which impair its performance. These challenges were grouped and classified into six major barriers: these include: *supervision and quality control, fluctuation and variations, subcontractor involvement, resistance to change, cultural issues, and lengthy approvals*.

Consequently, a Design Science Research (DSR) approach is adopted to evaluate the effectiveness of implementing LPS in construction projects in Nigeria. In order to achieve this aim, an Action Research strategy is adopted and three case studies are reported; two of these cases describe how LPS was successfully implemented in construction projects within Nigeria. While the third case involved an investigation into the state of production plan reliability, of a successful project in Nigeria. These projects were selected based on non-probabilistic sampling from different geographical locations in Nigeria to represent different kinds of construction projects within the country.

The first and second cases involved the implementation of LPS within the construction of a prototype student's hostel and the construction a 4 Kilometre single carriageway road respectively. The third on the other hand involved the construction of a multipurpose hydro-power dam project; where comparisons were made between typical LPS projects and the project management techniques applied within the project.

Data was collected through observation site activities, interviews, documentary analysis and questionnaire survey. The data generated was subsequently analysed by means of content analysis and evaluated in terms of its reliability, validity, representativeness, flexibility, rigour and reflexivity.

In view of the LPS implementation within the two case studies, six barriers were identified and classified together with the six barriers associated with the Nigerian Construction industry. These barriers were linked, measured and ranked in averages of their degrees of occurrences. It was revealed that the major barriers were *cultural issues* and *resistance to change*, while the others include; *lengthy approval, subcontractor's involvement, poor supervision and quality*, *fluctuations* and *variations.*

Hence, a framework was developed to mitigate these barriers, when implementing LPS in construction projects in Nigeria. The main steps of the framework include: the need to identify purpose; the need to identify stakeholders impact; the need to obtain Sponsorship; the need to build a cross functional team; the need to create measurement indices; the need for training on Lean techniques and LPS; and finally the need to create a right working climate.

Furthermore a focus group between construction practitioners was organised to test and evaluate the framework developed. It was revealed from the focus group that the framework has the potential to facilitate the implementation process as proposed.

ACKNOWLEDGEMENTS

I wish to express my profound gratitude to my Director of Studies, Dr. David Oloke for his insightful guidance, invaluable advice and supervision throughout this study. His resolute belief in my abilities and his unreserved support will always be remembered. I am also very grateful to Dr. Subashini Suresh and Professor Jamal Khatib, my supervisors for their immense contributions, unwavering support and guidance in shaping this dissertation, investing countless hours spent in research reviews, meetings, and ever-intriguing discussions will always be remembered.

My profound gratitude go to the people and organisations in Nigeria that contributed to the case studies, giving their priceless time and providing much valuable information that assisted in the completion of this research.

To my sponsors, Niger Delta Development Commission (NDDC); oversea postgraduate scholarship for Nigerian Students, I am indebted for your stable financial support.

Finally, I would like to thank my parents, Professor Chris Ahiakwo and Mrs. Roseline Ahiakwo for their continuous prayers, support, care, love and encouragement. To my siblings Barrister Obraori Uche Peters, Engr. Ndulaka Ahiakwo, Dr. Chukwuladi Ahiakwo and Ogorchukwu Ahiakwo, I am highly grateful for your prayers and moral support. Without the support of my family, this thesis would not have been completed.

DEDICATION

I dedicate this thesis to the Almighty God who granted me the wisdom, favour, insight and enablement to embark upon and complete this PhD.

LIST OF PAPERS PUBLISHED IN ASSOCIATION WITH THIS THESIS

Ahiakwo, O., Oloke, D., Suresh, S. and Khatib, J. (2012) A Critical Review of the Potential for the Implementation of Lean in the Nigerian Building Industry in: Tommelein, I.D. and Pasquir, C.L. (Eds) Procs 20th International Group for Lean Construction (IGLC) Conference, 18-20 July 2012, San Diego, California USA, 711-720

Ahiakwo, O., Oloke, D., Suresh, S. and Khatib, J. (2012) Client Perspectives For The Implementation Of Lean Construction In Nigerian Construction Industry in: Laryea, S.A., Agyepong, S.A., Leiringer, R. and Hughes, W. (Eds) Procs 4th West African Built Environment Research (WABER) Conference, 24-26 July 2012, Abuja, Nigeria, 133-146

Ahiakwo, O., Oloke, D., Suresh, S. and Khatib, J. (2013) A Case Study of Last Planner System implementation in Nigeria**.** Segue abaioxo o ISSN da 21st Conference of the International Group for Lean Construction July 31st - August 2nd of 2013, Fortaleza, Brazil. 2309-0979

Ahiakwo, O., Oloke, D. and Suresh, S (2014) Improving Project Planning and Control in Construction by implementing Last Planner Systems in Nigeria. International Council for Research and Innovations in Building and Construction (CIB W107 2014) 28th – 30th January 2014, Lekki Lagos, Nigeria.

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1. Chapter One - INTRODUCTION

1.1. INTRODUCTION

This chapter describes the research background, identifies the research questions and presents the aim of the research. It briefly discusses the objectives of the research while expatiating on the scope and motivations for undertaking the research. Additionally, a brief discussion of the main contribution to knowledge, motivation and the limitations of the research are also presented. The chapter then concludes with an outline of the thesis structure.

1.2. BACKGROUND OF THE STUDY

Generally, construction around the world is developing at a rapid rate both in terms of technology and organisation. Apparently, the construction industry earns its reputation from its perceived performance in terms of the value it produces. Construction processes are usually associated with several challenges and these vary from nation to nation. The construction challenges faced in the developed and developing countries differ from those faced in the under developed or emerging countries and invariably differ from nation to nation (Othman, 2013).

A developing country is regarded as a country where the average income is much lower than that of other advanced industrial countries usually referred to as developed countries (Akinwummi *et al*., 2008). The World Bank classifies developing countries as countries with low or middle levels of Gross National Product (GNP) per capita. While, Bannock (2005) classified developing countries as countries that have not yet reached the stage of industrialisation and most of these countries are in Africa, Asia and Latin America. Othman (2012) indicated that governments in developing countries are involved in the construction of infrastructural, industrial, educational, cultural, transportation, medical, and residential

projects that are required to provide the society with its basic needs so as to achieve its social and economic sustainable developmental objectives.

Nigeria is a typical developing nation in Africa, and it has the most developed economy in Africa (CIA, 2010); the country has been involved in gigantic developmental projects and the Federal Government of Nigeria in 2013 appropriated N1.62 trillion (approximately £6.48 Billion) for Capital Expenditure, with key allocations made for critical infrastructure development (Iweala, 2013).

Construction practices in Nigeria however, is characterised by many problems, some of which are further described in the subsequent chapters of this thesis. The industry is notable for its poor performances in terms of cost overruns in projects, poor project planning and control, poor project completion times and compliance with deadlines, and an increase in rework and defects (Oyewobi *et al.*, 2011, Olusegun and Michael 2011, Oke and Ogunsemi, 2011).

Several authors (e.g. Aina and Wahab, 2011; Olusegun and Michael, 2011; Oyewobi *et al.*, 2011; Windapo and Olusegun, 2010; Oke and Ogunsemi, 2011; Dlakwa and Culpin, 1990) have identified these problems without practically solving them. Furthermore, literature evidence shows that the studies stated above were basically explanatory or descriptive, dwelling only on the problems leaving out practical solutions. Conversely, Alsehaimi *et al.*, (2009) proposed that rather than solely conducting explanatory studies, which usually do not on its own offer practical solutions to problems in construction management; novel management techniques like Lean Construction could be developed and practically implemented to proffer solution to some of these problems.

In recent times however, the Lean Construction community advocates that research should be centred on the development of solutions that are explicitly aimed at solving practical problems (Koskela, 2008). Similarly, in order to address these prevailing problems within the

Nigerian construction industry, authors have suggested that only a novel research approach that could go beyond the normal explanatory or descriptive research or a non-traditional research approach such as design science, constructive research and action research is required to practically tackle some of these persistent construction management difficulties, and contribute to knowledge in construction management (AlSehaimi *et al.*, 2009; Jang *et al.*, 2010; Azhar *et al,* 2010; Azhar, 2007; Järvinen, 2007; Koskela, 2008; Voordijk, 2009; Van Aken, 2005).

In challenging the traditional approach of construction, Lean Construction advocates for collaborative production planning while emphasising on the reliability of workflows, promotion of pull-based culture and an improved communication system (Ballard *et al*., 2009, Mossman, 2013). Similarly, it promotes trust and transparency with the sole aim of maximising customer value and improving the performance of the industry (Howell and Ballard, 1998; Ballard *et al* 2009; Ballard *et al* 2002; Alsehaimi *et al.*, 2009; Thomas *et al.*, 2003). The practice of Lean Construction in most countries has recorded an improvement of project performance and the entire construction process (Gonzalez *et al*., 2010; Alarcon *et al.*, 2005; Thomas *et al*., 2003).

The most developed practical use of Lean Construction, that focuses on reducing the negative impacts of variability, making projects more predictable, minimising buffers, reducing uncertainties, improving collaborative planning, creating reliable work plans is the Last Planner System (LPS) (Ballard 1994, 2000; Ballard and Howell, 1998; Ballard *et al.*, 2009; Koskela *et al.*, 2010; Tommelein & Ballard, 1997; Ballard and Howell, 2004; Hamzeh *et al.*, 2008).

LPS has five main elements: the master plan, phase plan, look-ahead plans, weekly work plans and the calculation of percentage of plans completed (Koskela *et al.*, 2010; Tommelein & Ballard, 1997; Ballard & Howell, 2004; Ballard, 1997; Hamzeh *et al.*, 2008). LPS has been

successfully implemented in many countries across the world and known to improve planning, control, project performances, productivity, communication, collaboration and learning (Mossman, 2012; Ballard *et al.,* 2009, Gonzalez *et al.,* 2010; Fiallo and Revelo, 2002; Alarcon, 1997; Tommelein and Ballard, 1997). However this has not been the case in Nigeria.

In view of the benefits of LPS and the peculiar problems associated with the Nigerian Construction industry, this research put forth this research question.

1.3. RESEARCH QUESTIONS

The development of the research question involves a process of examining an issue, in an area of interest and which might pose a problem (Lipowski, 2008). Hence a question is formulated around it to solve the perceived problem.

Consequently, the research question for this study is as follows:

> *Can Lean Construction tool; the Last Planner System, be successfully applied to improve construction processes within Nigeria?*

The research question for this study was therefore selected based on these criteria: (1) the research question should be specific i.e. to a subject area. (2) The question should not be too narrow. (3) The question should be simple and interesting to the researcher and (4) the question should possess answers that can be measured in practice (Creswell, 2003; Cheshire, 2007).

1.4. RESEARCH AIM

This research aims to evaluate the effectiveness of implementing LPS in construction projects in Nigeria.

1.5. RESEARCH OBJECTIVES

In order to answer the research question and to achieve the research aim, the following research objectives are pursued:

1. *To critically review literature on Nigerian construction processes, identifying inherent problems facing the construction industry.*
2. *To critically review Lean Construction and Last Planner implementations in other countries, drawing up the possible barriers of LPS that could be experienced in Nigeria in addition to the inherent problems of the Nigerian construction industry.*
3. *To implement LPS in multiple construction projects in Nigeria and measure the barriers identified from the literature reviews as possible barriers to the implementation*
4. *To compare typical LPS projects with a successful construction project in Nigeria, to identify similarities and differences between both processes.*
5. *To develop, test and validate a framework for the effective implementation of LPS in Nigeria to mitigate the barriers to LPS identified.*

1.6. RESEARCH SCOPE

Although the construction industry in itself is very broad, the scope of this research is limited in the following ways:

- To local indigenous construction companies handling medium sized projects in Nigeria.
- To the construction stage of the project only whilst at the same time focusing on planning, controlling and management aspects of the project.
- To the implementation of LPS in two construction projects.
- To the Last Planner System (LPS) which is only one of Lean Construction's tools.
- To the development of a framework based on the existing body of literature and the findings from the case studies.

1.7. RESEARCH MOTIVATION

This research was developed as a result of the researcher's discontent with the way construction activities were handled in Nigeria. The researcher, having previously worked as a construction engineer for seven years on different challenging projects, and currently involved in the administration of government construction projects in Nigeria, observed that the construction industry is suffering from inherent problems, characterised by poor project planning and control, poor quality work, overruns in schedule and all forms of delays.

However, during these years, the researcher developed a strong ardour for analysing and seeking for initiatives that would improve the standard of construction operations in Nigeria. This zeal inspired this research on Lean Construction, in a bid to address the aforementioned concerns being experienced by the Nigerian construction industry.

The idea of Lean construction began during the researcher's Master's Program on Construction Project Management, at the University of Wolverhampton**.** During this program one of the modules dealt extensively on the Egan report 1998 - 'Rethinking Construction". From the explanations given in the report, Lean Construction and the Last Planner System were explicitly identified as improvement initiatives.

In the same vein, further research on the adoption of Lean by different organisation in different countries have recorded improved labour flow reliability (Thomas *et al.,* 2003), improved planning reliability and project performance for better productivity (Gonzalez *et al.*, 2010, Ballard, 1999).

In the words of Stephen Covey (Smith, 1994) – *"All things are created twice; first mentally; then physically. The key to creativity is to begin with the end in mind, with a vision and a blueprint of the desired result."* Consequently, the research adopts the philosophy of four causes "How things came into existence" by Aristotle as a rationale, while bearing in mind that "*it is always easier to talk about change than to make it."*- Alvin Toffler (Toffler, 1970).

The researcher's rationale falls under the four causes of Aristotelian principles influential to change which are: (1) the material cause; (2) the formal cause; (3) the efficient cause and (4) the final cause – (Aristotle 350 B.C 1970)

The Material cause explains what the object is made up of. Here Lean Construction (being the object) is made up of five principles, some tools and techniques which improve managerial practices within construction organisations. These principles include: 1) Specify value; 2) identify the value stream; 3) create a flow for the value 4) pull and 5) perfection (Womack and Jones, 1996). While some of the tools and techniques include: visual management, daily huddle meetings, 5S, first run studies, Last Planner System etc (Salem *et al*., 2005).

The formal cause pertains to the essence of something or what the inherent characteristics of the substance is composed of. Here Lean Construction and its most developed tool – the Last Planner System, is characterised as practical improvement initiatives, known to unambiguously minimise waste of material, time and efforts, while generating the maximum amount of value (Mossman, 2013).

The efficient cause on the other hand explains the source of the change. This infers that it points to the person who is working on the object of change. This is however defined by the researcher's quest for improving construction processes in Nigeria and his pursuit for a career in academia, which entails obtaining a PhD and creating a foundation for future research in an innovative improvement initiative i.e. Lean Construction via the Last Planner System, which will serve as the change agent to the construction processes in Nigeria.

The final cause is concerned with the purpose the object will serve. It explains the reason why something is made. Consequently, for the sake of contributing to knowledge and improving construction process in Nigeria, or contributing to the good in the world in general, is the main reason this research was undertaken. Other reasons for undertaking this

research was for the sake of self-satisfaction and the actualisation of attaining a PhD degree in Construction Management.

1.8. STRUCTURE OF THESIS

This thesis consists of nine chapters. The structure of the thesis (and research) is illustrated in figure 1.1. The first chapter provides an overview of the research. It commences with a background to the research and highlights the research questions, research aim and objectives. It further sets out the research scope, the primary contribution of the research and the motivation of the research.

Chapter two presents the context of the environment under study and provides insights into the geographic, economic and performance of the construction industry in Nigeria.

Chapter three presents a review of the literature on the roots of Lean Construction and illustrates critiques existing in this body of knowledge. It assesses techniques and tools that could be used during implementation, while focusing on the Last Planner System. Furthermore, the chapter highlights the previous applications of the Last Planner system, its benefits and challenges during implementation.

Chapter four introduces the research methodology and justifies the use of Design Science Research methods. An action research cycle is described and the data collection strategy based on longitudinal case studies is outlined. The analysis and evaluation of the data is discussed to support both the implementation of lean construction and the development of an implementation framework.

Chapter five presents the first case study where the Last Planner System is implemented and tested within an ongoing building project in Nigeria, using an Action Research approach. Various methods of data collection including interviews, observation and questionnaire were employed and the findings are discussed.

Similarly, Chapters six and seven also described the second and third case studies reported in this thesis. The research activities within these chapters included interviews, observations and questionnaires are highlighted and the summary of the data findings are discussed.

Chapter eight evaluates the findings of the research, while synthesising the action research cases studies. It further examines the barriers to the implementations recorded within the three case studies and harmonises them with those identified from the literature reviews. Consequently, mitigation measures to these barriers are suggested and a framework for the implementation of LPS is proposed. The framework is further validated using focus group discussions. The chapter is summarised by discussing the outcomes of the focus group.

Chapter nine; the final chapter, presents the conclusions of the research. It closes the thesis by providing answers to the research questions, including the achievement of the research aim and objectives as they were initially formulated. Subsequently, the chapter highlights the contributions made to existing knowledge and practice in construction project management. It further outlines the limitations of the research and also suggests possible recommendations for construction industry practitioners, and some recommendations for future research.

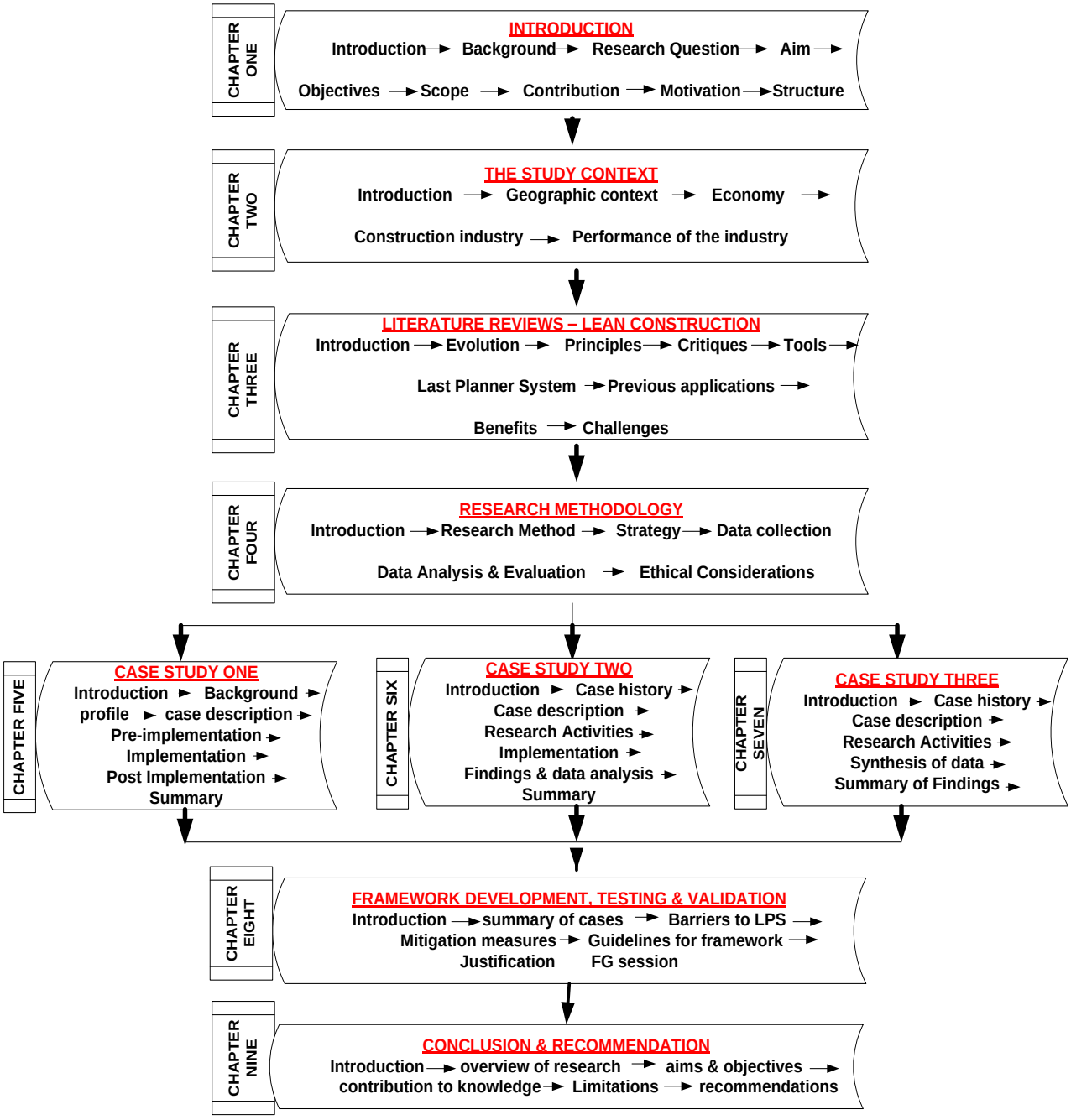


Figure 1.1 Structure of the Thesis / Research Process

2. Chapter Two - THE STUDY CONTEXT-NIGERIA

2.1. INTRODUCTION

This chapter presents a general overview of the study context, Nigeria. It provides an insight into the local conditions of the country, the economy of the country and the construction industry. The chapter is divided into four sections. The first section presents the geographic context in which the study was conducted, whilst the second section reviews the Nigerian economy. The third section highlights an overview of the Nigerian construction industry, whilst the fourth discusses the performance of the construction industry. The chapter concludes by describing the current problems associated with the industry and how this research is well poised to tackle some of these acts as a pre-cursor to further solutions.

2.2. GEOGRAPHIC CONTEXT OF NIGERIA

Nigeria, officially referred to as the Federal Republic of Nigeria, is a country in West Africa and shares land borders with the Republic of Benin in the West, Chad and Cameroon in the East, Niger in the North and boarders of Gulf of Guinea in the South and the Atlantic Ocean (Internet World Stats, 2009). The country has an area of 923,768 sq km with an estimated population of over 158.3 million (Trading Economics, 2011) and the most populous country in the entire African Continent. Nigeria accounts for 47% of West Africa's population and ranks 8th amongst the top ten countries with the highest population in the world (Internet World Stats, 2011).

Nigeria consists of 36 States plus a Federal Capital Territory, while since 1991 the country's capital has been centrally located in the city of Abuja. Previously, the Nigerian government was headquartered in Lagos. The country is known to have over 274 ethnic groups in the Federation which is divided into three major regions and grouped under six geopolitical zones with a total of 774 Local Government Areas (LGAs) (Gbenga-Ilori and Ibiyemi, 2010).

Nigeria ranks 32 in the world in terms of total area. The terrain of the country consists of southern lowlands and plateaus in the central region. The south east region has a mountainous surface, while the north consists of plains (CIA, 2011)

Figure 2.1 Geographic Context of the Study - Nigeria Map (Adapted from CIA, 2011).

Nigeria's economy has been noted to be the fastest growing in Africa and was observed to have the potential of being the largest and strongest in the entire world, given the amount of abundant human and natural resources within it (Kolapo, 2008). On the other hand, it is also observed that the economy is heavily dependent on the oil sector and that Nigeria is Africa's largest producer of oil and the fifth largest oil exporter to the United States (Ploch, 2011). The construction industry in any country is supposed to be a leading driver of economic development (Dantata, 2008), since all sectors including the oil sector largely depend on the products and services of the construction industry.

2.3. THE NIGERIAN ECONOMY

The Nigerian economy is noted to be the fastest growing in Africa and is also one of the most developed economies in Africa. However, the Nigerian construction industry continues to occupy an important position in the Nigerian economy even though it contributes less than

the oil industry. The activities of the industry are vital to the achievement of national socio-economic developmental goals of providing shelter, infrastructure and employment (Oladinrin and Ogunsemi, 2012); and it has the potential of being the largest and strongest in the entire world, given the amount of abundant human and natural resources within it (Kolapo, 2008). Similarly, the United Nations classified Nigeria as a middle-income nation with developed financial, communication and transport sectors. It is also reputed to have the second largest stock exchange in the continent (CIA, 2010)

The Nigerian economy has had a truncated history since the independence of the country in 1960; the economy has been weak, constricted and externally-oriented (Isa *et al.,* 2003). Furthermore, the economy is yet to achieve the structural changes required to swiftly jump-start any sustainable developmental growth especially with its disarticulated and constricted productive base (Oluwakiyesi, 2011). Although the primary production activities of the economy, accounts for over 90% of the foreign exchange earnings and 75% for that of employment (NBS, 2011). While the secondary activity which is made up of manufacturing and construction accounts for only 1.14% and 2.0% of the total gross output respectively (NBS, 2011). These activities are supposed to have a greater potential for employment generation, broadening the productive data of the economy and generating sustainable foreign exchange earnings.

Additionally, CIA (2010) identified the petroleum industry to be central to the Nation's economic profile. However, the Nigerian economy is highly amorphous and lacks basic infrastructure. Several failed efforts have been made after 1990 to develop other industrial sectors especially the construction sector. The country ranks 151 out of 177 on the UN Development Index and the government have initiated strategic economic reforms to eradicate poverty and bring economic equality which have been a setback to the Economy

(CIA, 2013). Additionally, corruption has been the main impediment to the success of any such effort.

Although as pointed out in CIA (2013), the Nigerian government since 2008 has started showing the political will, by putting into operation more robust market-oriented reforms such as; modernising the banking systems, removing subsidies, and resolving regional extensive disputes over the distribution of earnings from the oil industry. Hence, this has prompted the GDP to advance stalwartly in 2007-12 because of the robust global crude oil prices and the growth in non-oil sectors e.g. construction.

In addition, CIA, (2013) also reported that the presidency has been working assiduously to increase transparency, diversify economic growth, and improve fiscal management. Even though, the lack of infrastructure and the slow implementation of these reforms are major impediments to the growth of the economy. The contribution of the construction industry to the national economic growth of the country necessitates improved efficiency in the industry by means of improving the construction processes within the country. The building and construction sector is one of the top sectors used in measuring the National Gross Capital Formation (NGCF) and the GDP of any country (Isa *et al.*, 2013), with the building and construction sector currently contributing 1.8% to the GDP of the economy in 2013 (Ekpo and Umoh, 2013).

Here are some of the vital statistics related on the Nigerian economy as sighted in CIA, (2013):

Table 2.1 Statistics of the Nigerian economy (CIA, 2013)

GDP - real growth rate	6.3% (2012 est.) 7.4% (2011 est.) 8% (2010 est.)
GDP - per capita (PPP)	$2,800 (2012 est.) $2,700 (2011 est.) $2,600 (2010 est.)
Gross national saving	24.4% of GDP (2012 est.) 19.4% of GDP (2011 est.) 20.4% of GDP (2010 est.)
GDP - composition, by end use	Household consumption: 53.2% Government consumption: 14.9% Investment in fixed capital: 18.4% Investment in inventories: 0% Exports of goods and services: 44.2% Imports of goods and services: -30.7% (2012 est.)
GDP - composition by sector	Agriculture: 30.9% industry: 43% Services: 26% (2012 est.)
Population below poverty line	70% (2010 est.)
Labor force	53.83 million (2012 est.)
Unemployment rate	23.9% (2011 est.) 4.9% (2011 est.)
Budget	Revenues: $22.35 billion Expenditures: $27.87 billion (2012 est.)
Taxes and other revenues	8.3% of GDP (2012 est.)
Industrial production growth rate	1.7% (2012 est.)
Exports	$92.16 billion (2012 est.) $92.5 billion (2011 est.)
Imports	$54.6 billion (2012 est.) $61.65 billion (2011 est.)

2.4. THE NIGERIAN CONSTRUCTION INDUSTRY

The construction industry, like in most developing countries is a leading driver of economic development. This is because every other sector largely depends on its products or services in order to fully operate (Oladinrin *et al.,* 2012). However, the industry is still fraught with a lot of intrinsic challenges, ranging from inadequate technical and managerial know-how to insufficient financial, material and equipment capital base (Ofori, 2001).

Although the industry has a lot of potential; an example is the self-sufficiency in cement production, which on its own can alleviate the materials challenges and huge deficit in physical infrastructure such as roads, rails, airports and sea-ports (Oluwakiyesi, 2011). For instance, it would be impracticable for any industry to function without any infrastructure in place or if there are no access or link roads for the transportation of raw materials or if there is no office building or other construction outputs. Hence, the construction industry plays an important role in the economy, and there is hope for the Nigerian construction industry in the coming years, with emphasis shifting to infrastructure growth.

In Nigeria, the construction industry is typically dominated by small and medium sized local contractors who are mainly involved in private residential projects (Bashir *et al*., 2010). These small and medium sized local contractors are usually grouped as informal or unorganised sector of the industry (Dantata, 2008). This group as noted by Dantata (2008) comprises of simple residential building projects built by private clients constructed through the effort of hired artisans and labour and in some cases, the owner supervises the construction directly, with the government not having any direct influence on the sector.

However, the major contractors, which are referred to as the organised sector (Dantata, 2008) comprises of established contractors who are legally registered to carry out construction

projects and they are usually made up of highly skilled workers, both expatriate and local labourers. These companies operate under a set of given rules and regulations of the country.

2.5. THE PERFORMANCE OF THE NIGERIAN CONSTRUCTION INDUSTRY

Similar to other Sub Saharan African (SSA) countries, the Nigerian construction industry is faced with enormous challenges which are constantly mitigating the development of infrastructure and the growth of the sector (Oluwakiyesi, 2011). The industry has been performing far below standards. This is basically because it is beset with many problems. These include poor quality work, cost and time overruns (Oyewobi *et al.*, 2011), resulting from poor project definitions during planning; inadequate planning; inadequate funds; inflation; bankruptcy of contractor; variation of project scope; political factors; death of client; incompetent project manager; wrong estimate; inadequate cost control (Olusegun and Michael 2011, Oke and Ogunsemi, 2011), incomplete designs during the design stages (Aina and Wahab, 2011; Windapo and Martins, 2010), unethical behaviours in the form of fraudulent practices and kickbacks (Mansfield *et al.*, 1994; Olomolaiye *et al.*, 1987), waste generation due to bureaucracy, variations, delay from suppliers and poor site management (Oke and Ogunsemi, 2011; Dlakwa and Culpin, 1990).

Different authors have enumerated the basis of these problems within the industry.

Table 2.2 Review of reasons for the decline of the Nigerian construction industry

Authors	**Causes of problems within the Nigerian industry**
Aina and Wahab (2011)	Complexity of project; faulty defective working drawings; lack of proper tools and equipment's by contractors; incomplete specification; resistance of client to changes; budgetary limitations; non-standardisation of design; lack of construction experience by the client; poor communication; lack of mutual

	respect between the designers and contractors.
Olusegun and Michael (2011)	Inadequate planning; inadequate funds; inflation; bankruptcy of contractor; variation of project scope; political factors; death of client; incompetent project manager; wrong estimate; inadequate cost control; faulty design; delayed payment of contractor and suppliers
Windapo and Olusegun (2010)	Contractor competence; external factors; contract delays; differing site conditions; labour; equipment and material availability; changes in scope of work; defective designs; inflation; labour disputes
Oyewobi *et al* (2011)	Poor contracting documents; poor planning; lack of transparency; presence of unqualified individuals; inadequate finance; decline in competence of trained professionals and artisans.
Chan and Kumaraswany (1997)	Poor site management and supervision; unforeseen ground conditions; poor decision making involving all project teams; client initiated variation
Mansfiel *et al* (1994)	Poor contract management; shortages of materials; changes in site conditions; weather; design changes; mistakes and discrepancies in contract documentation; none adherence to contract conditions; labour and management relations; inaccurate estimates; fraudulent practices and kick backs
Dlakwa and Culpin (1990)	Contractors and financial difficulty; frequent variation; deficiency in planning; scheduling; unrealistic tenders;

	deficiencies of construction plants and equipment; inadequate site inspection; shortage of qualified workers; bureaucratic obstacles.
Olomolaiye *et al* (1987)	Lack of materials; repeat work; lack of proper tools and equipment to carry out the work; supervision delays and absenteeism; clients not ensuring strict compliance to contract conditions; paying contractors mobilization fee prior to the start of work; price fluctuation; irregular supply of materials; poor plant maintenance.

Most of these studies stated above were identified to be exploratory in focus, dwelling only on the problems living out solutions to the problems mentioned. Conversely, Alsehaimi *et al.*, (2009) proposed that rather than solely conducting explanatory studies, which usually do not on its own proffer practical solutions to problems in construction management; novel management techniques could be developed and practically implemented in non-traditional research approaches such as constructive and action research. This may help to tackle some of the persistent construction management difficulties, and contribute to knowledge in construction management.

Irrespective of the inherent problems associated with the Nigerian construction industry, Sun and Aouad (2000) revealed that construction in any country have the following challenge:

- Fragmented supply chain.
- Lack of industry standards for information exchange.
- Poor cross-disciplinary communication.
- Lack of process transparency.
- Poor knowledge management at industry, enterprise and project levels.

However, it was observed that many countries already realised that there is a need for change in construction and initiated various initiatives and programs for achieving that desired change. Table 2.3 highlights these initiatives

Table 2.3 Change initiatives in different countries (Source: Koskela et al., (2003))

Country	**Programme**
Australia	Building regulation reform, Building for growth
Denmark	ProjectHUS
Finland	Vision 2010
Hong-Kong	Quality reform initiative
The Netherlands	BowBeter
Singapore	Construction 21
United Kingdom	Rethinking Construction
USA	FIATECH

Nigeria being a former British colony, obtained her independence in 1960. This is the result of the existing cordial relationship between Nigeria and the United Kingdom. The United Kingdom on the other hand is one of the most experienced countries in terms of implementing conscious change in construction. The UK government set up research investigations into old construction practices and these resulted in the development of different change initiatives. These initially consisted of the Simon Report in 1944, the Emerson Report in 1962 and the Barnwell Report in 1964. More recently, the Latham Report "Constructing the Team" in 1994, the Levene Report "Construction Procurement by Government" in 1995 and the Egan Report "Rethinking Construction" in 1998 were also commisioned (Cooke and Williams, 2004).

Cooke and Williams (2004) stated that the (1998) 'Rethinking Construction' Egan report explicitly mentioned Lean Construction and the Last Planner System (LPS) as improvement initiatives to be adopted in construction. Mossman (2013) indicated that as a result of the Egan 1998 report; BAA, the UK airport operator adopted LPS for all its projects from 1999 till date while other similar organisations are also practicing Lean Construction and its Last Planner tool.

In view of the foregoing, Ahiakwo *et al.,* (2012) reviewed the potential of improving Construction processes by practically implementing the Last Planner System (a lean construction tool) within the Nigerian Construction industry. It was identified that there was a huge potential of solving the problems associated with the Nigerian construction sector if the Last Planner system could be practically implemented within construction projects.

Although, other improvement and change initiatives has been suggested by a few authors to help tackle some of these persistent challenges of the Nigeria construction industry. For example Obunwo *et al.,* (2013) proposed a quality management system; Ojo *et al.,* (2014) proposed Green supply chain management; Aniekwu and Igboanugo (2012) proposed the use of Concurrent Engineering; while Aniekwu (2004) proposed the application of matrix management system in the construction processes using the concept of 'Partnering'.

However, these initiatives met stringent barriers which made the prevalence of the challenges still dominant. A case in point, Obunwo *et al.,* (2013) identified 10 key barriers, which include: proper project definition, information management, teamwork, risks, leadership, team management, training, incremental over exponential change, funding and focus on numbers.

While Ojo *et al.,* (2014); used a qualitative approach to analyse barriers in implementing green supply change management in Nigeria. The results revealed the following barriers: lack of public awareness, lack of knowledge and environmental impact, poor commitment by top

management, lack of legal enforcement by government, lack of resources, lack of sustainable practices, lack of market, lack of information sharing, lack of demand.

On the other hand, Aniekwu and Igboanugo (2012); indicated that the most challenging barriers to the change initiatives and the uptake of Concurrent Engineering in the Nigerian construction industry are environmental factors, these relate to the shortage of the environmental infrastructure (market, political and regulatory), as well as the security of the environment to support the implementation of Concurrent Engineering. Similarly, Aniekwu (2004) indicated that key barriers to the success of the matrix management system are cultural roots of co-operation and mutual trust.

Furthermore, these challenges highlighted above in addition to the challenges of the Nigerian construction industry enumerated in table 2.2 are classified into six major clusters and linked with key participants responsible for these challenges. This classification is shown in table 2.4.

Table 2.4 Classification of challenges of Nigerian Construction industry into six clusters

S/n	Barriers from previous research	Cluster of major issues	Key participant
1.	Poor project definition, leadership, lack of sustainable practices, complexity of projects, incomplete specifications, faulty working drawings and designs, inadequate planning and poor control of work flow	Poor supervision and quality	Project Manager in charge of the project
2.	Risks, inflation, bankruptcy of contractor, variations, political factors, weather conditions and inevitable natural forces	Fluctuations and variations	External factors and the type of contract

3.	Lack of team work, lack of mutual respect between consultants, fragmentation and subcontracting, poor site management by contractors and suppliers, labour disputes and delay from suppliers	Lack of subcontractors involvement	Suppliers and contractors
4.	Lack of public awareness, inadequate training of staff, lack of information sharing, resistance to change, unclear strategic goals, poor organisational structure and management	Resistance to change	The entire work force
5.	Lack of information sharing, lack of knowledge of improvement initiatives and opportunities, poor communication, unethical practices	Cultural issues	The entire project team
6.	Traditional procurement methods, poor government control and enforcement, budgetary limitations, delay in payments, fluidity of funds, lack of legal enforcement, wrong estimates, client uncertainty and inconsistency, poor top management commitment and unrealistic expectations	Lengthy approval	Client

Clearly, these problems linked to the Nigerian construction industry are as a result of poor project management practices and Howell (1999) had proposed that Lean Construction could be a solution to the limitations of project management theories. More recently, Bashir (2013) developed a framework utilising lean construction strategies to promote safety on

construction sites in UK, while Alsehaimi (2011) investigated how Lean construction principles could possibly improve construction planning in Saudi Arabia. Hence the next chapter discusses further on Lean Construction and how it could be a possible solution the limitations of project management associated as the challenges facing the Nigerian construction industry.

2.6. SUMMARY

This chapter presents an overview of the study area Nigeria. It describes the geographic context of Nigeria as the largest population in the African continent. The chapter also describes the Nigerian economy in relation to the construction industry. Furthermore, a review on the performance of the industry is presented; the summary indicates that the level of productivity of the industry was very low and different authors have reported the industry to be characterised by poor quality work, cost and time overruns, resulting from poor project definitions during planning; inadequate planning; inadequate funds; inflation; bankruptcy of contractor; variation of project scope; political factors; death of client; incompetent project manager; wrong estimate; inadequate cost control, incomplete designs during the design stages, unethical behaviours in the form of fraudulent practices and kickbacks, waste generation due to bureaucracy, variations, delay from suppliers and poor site management.

These challenges were however grouped and classified into a cluster of six major issues. These major issues include: lengthy approval, cultural issues, fluctuation and variation, supervision and quality control, subcontractor's involvement and resistance to change.

Similarly, from the literature reviews it was observed that previous research on construction management in Nigeria only conducted exploratory studies mentioning only the problems and leaving out possible solutions.

3. Chapter Three - LEAN CONSTRUCTION

3.1. INTRODUCTION

The previous chapter highlighted both the inherent problems and shortcomings of current construction planning practices in Nigeria which have resulted to poor quality, perennial problems of time and cost overruns. This has however necessitated a radical change in industry practice in order to improve the quality of construction processes. Hence, this chapter provides a review of current literature surrounding Lean Construction and the Last planner system, which was introduced in the previous chapter as an improvement initiative for the Nigerian construction industry. The Chapter commences with a discussion on the management concepts of Lean Construction, its historical developments and critical arguments surrounding Lean. Key Lean Construction tools are also examined with a focus on the Last Planner System. Furthermore, a number of issues facing the adoption of the Last Planner System are discussed and summarised.

3.2. EVOLUTION OF THE MANAGEMENT CONCEPTS OF LEAN CONSTRUCTION

Lean Construction emerged as a new management discipline from the manufacturing philosophy and 'Lean' was first identified by Toyota in Japan (Ohno, 1988; Koskela *et al*., 2002). Taichii Ohno Toyota's chief engineer was the main pioneer and promoter of lean thinking for Toyota. He drew so much attention with this new philosophy and it became popular, this made Toyota gain advantage over its competitors and rivals by eliminating both hidden and obvious wastes (Ohno, 1998).

'Lean production' as a term was first coined and became extensively popular by Womack, Jones and Ross (1990) in their book '*The Machine that changed the World'*. There the authors even suggested that the Lean philosophy is destined to become the sole production system to be adopted in the whole world, after it was compared with mass production.

For several years, this claim by the authors made lots of substantiated claims that have been criticised and debated. However, Womack *et al.,* (1990) suggested that Lean Production is concerned with producing high quality goods at low prices. This was supported by Legge (1995) sighted in Garnett (2001, Pg 7) on the basic characteristics of Lean Production: "*lean involves changes in the vertical division of labour, with an emphasis on product innovation, improved design capability, relations with suppliers and responsiveness to local markets*". While Ballard (1999) categorises Lean Production as a concept that aims to systematically eliminate waste, simplify production procedures and speed up production. This implies that, it is a value seeking tactic that aims to maximise value and pursue perfection in a continuous approach.

Simply put by Ganen (2012, Pg.4), "*Lean tries to create or conserve value for the customer while using fewer resources*". The author also adds that "*in order to achieve this ultimate goal of providing value to the customer through a value creation process that has zero waste, lean changed the focus of management from optimising each process within the production line to designing a new production process that optimises the flow of products and information through the entire value stream. This way creating processes that uses less human effort, takes less space, requires less capital, spends less time and provides products with much less defects than the traditional production practices*".

Ohno (1998) who defined the basic concepts of Lean Production as:

- Pull-driven
- Minimising wastes by eliminating non-value added activities
- Identifying and resolving defects instantly at the source by doing things right the first time
- Continuous improvement

- Building long term relations with suppliers
- Building team work

Lean Production continues to evolve but the guiding principles is clear and was termed ‘Lean Thinking’ in Womack and Jones (1996) and Marchwinski and Shook (2004), described Lean Thinking as a technique for organising and managing product development; operations; suppliers and customer relations that involves less human effort, less space, less capital, less material and less time to make products with fewer defects to specific customer requirements. The basic principles of this strategic approach ‘Lean Thinking’ is discussed below.

3.3. THE PRINCIPLES OF LEAN THINKING

These basic principles are: Specify value for specific products; identify the value stream for each product; make the value process flow without interruptions; customers pull and perfection (Womack and Jones, 1996).

3.3.1. SPECIFY VALUE FOR SPECIFIC PRODUCTS

This principle of Lean when applied in construction is usually complex and difficult to specify. This is because value is viewed from a customer perspective in terms of the customer’s satisfaction; i.e. the customer receiving exactly what he wants, how he wants it, when he wants it and how much his willing to pay for it (Womack and Jones, 1996; Gray, 1996). Similarly, Ballard (2000) in his research pointed out that value in construction is also determined from the client brief and the specifications of the project.

3.3.2. IDENTIFY THE VALUE STREAM FOR EACH PRODUCT

Identify the value stream principle as stated in Howell and Ballard (2003) involves value stream mapping. These maps establish the way decisions about the process are made. It involves identifying the steps and chains of the process that creates value (Womack and

Jones, 1996). These maps also serve to understand how the design of planning, logistics and supply chain interaction support customer value (Green, 1996). Furthermore, Rother and Shook, (1998) observed that value stream maps displays the connection between the flow of information and material. They provide a clear view of the sources of waste within a process.

3.3.3. MAKE VALUE FLOW WITHOUT INTERRUPTION

The flow principle eliminates the waiting time for work-in-progress. Womack and Jones (1996) identified flow as a continuous value adding process where once a task starts it continues till it is completed. In this principle, the entire process is viewed holistically and each of the dependency within the process is observed with the aim of eliminating, delays, defects, rework, errors and all forms of wasteful activities or materials (Koskela, 1992). Similarly, Howell and Ballard (2003) recounted that this principle eliminates those places within a process where value adding work on the material or information interrupted.

3.3.4. COSTUMERS SHOULD PULL FROM THE PRODUCERS

This principle is described in Womack and Jones (1996) as a mechanism that prevents inventory of material. It entails pulling work from the upstream by those downstream. This is done in three ways; the replenishment pull system, the sequential pull and the mixed pull system (Society of Manufacturing Engineers, 2005). The pull system generally recognizes that the entire process is not an end in itself but it requires a step by step input for the whole to be formed. This implies that each step should be delivered in the right time and quantity to avoid waiting or any of the inventories stated in Howell and Ballard (2003); materials and design information, labour and its tools, intermediate work product etc.

3.3.5. PURSE PERFECTION

The pursing perfection principle of lean simply connotes striving to be the best continuously. It entails the continual improvement of the system by eliminating waste and creating value increasingly (Dulaimi and Tanamas 2005).

Furthermore, Womack and Jones (1996) tried to translate Lean Production into other industries after it became highly popular within the Western manufacturing industries, and then the Lean philosophy also entered the construction sector. The Lean philosophy as applied to construction was first recognised in construction management literature in 1992 by Lauri Koskela in his work *'Application of the New Production Philosophy to Construction'*. After this work, other publications have made the waves within this subject matter, with the work of the International Group for Lean Construction (IGLC) covering a wide range of interests.

Currently, problems associated with the construction industry such as low productivity, poor safety, and insufficient quality led the industry to seek for solutions to relieve the problems. Hence practitioners sort to adopt the new production philosophy (Lean) within construction (Koskela, 1997). However some other Lean Construction literature from leading authors covering a diversity of concepts has led to the practical development of lean tools such as the Last Planner System (Ballard, 1993).

The concepts of Lean Construction have already been brought to the construction industries of some developed and developing countries like: Australia, Brazil, Demark, Ecuador, Germany, Finland, Netherlands, Japan, Korea, Peru, Singapore, UK, USA (Ballard and Howell, 2003; Lee *et al*., 1999). However, there appears to be an on-going critical debate around 'Lean'. A number of these critiques have been channelled to Lean Production as opposed to Lean Construction where there have been little critical debates on its potential

benefits and disadvantage. These extensive criticisms on Lean Production emerged from the self-acclaimed superiority of Lean Production over all other systems (Womack *et al.,* 1990). The proceeding section briefly discusses some critiques that have been directed towards Lean Production and Lean Construction.

3.4. CRITIQUES TO LEAN

The main criticism to the Lean philosophy is that it is just a collection of tools that can be adopted and applied in any one-off improvement event, with 'lean' champions claiming that it is superior over other production systems like the mass production system (Lewis, 2000; Williams *et al.,* 1995; Cusumano, 1994; Berggren, 1990).

Lean Production principles have been linked to different problems; ranging from unexpected shortage of materials, human exploitation of workers and hazardous events (increased pollution to the environment) occurring and even the 1996 Kobe earth quake in Japan was linked to the effects of Lean Production (Green, 2002; Lewis, 2000; Pheng and Tan, 1998; Williams *et al.,* 1995; Cusumano, 1994; Berggren, 1993).

Williams *et al.,* (1995) argued that the Lean Production theories do not encompass the influence of political and social institutions in which supply systems function. Berggren (1993) added that the claims done in '*The Machine That Changed the World'* by Womack, (Womack *et al.,* 1990) as regards the cross-national comparison of production data, was misleading and non-factually correct because it had omissions of crucial parameters.

Similarly, Cusumano (1994) argued that Japan while practising Just-in-Time as a continuous improvement concept of Lean, suffered from increased traffic, too many variations and over stressed suppliers. In the same vein, Green (2002) emphasised that Lean Production in Japan resulted in over working of the workers in a stressful working environment with frequent overtimes, inflexibility, unlimited demand and restrictions of workers to form unions.

Pheng and Tan (1998) summarised some of the potential benefits of Lean Production systems with its obvious short comings in the table below.

Table 3.1 Benefits and Shortcomings of Lean Production system (source Pheng and Tan 1998)

Potential benefits	***Possible shortcomings***
Reduces inventory	Not flexible
Reduces factory overhead	Not responsive
Reduces production costs	Disruption of workflow
Reduces ratification cost	Harsh working conditions
Improvement in quality	Over-Focus on Waste
Improvement in productivity	Possible sabotage from suppliers

On the other hand, 'Lean' applied within construction have been criticised on being immature and has been promoted from a one sided positive view (Green, 1998; 1999; 2000; 2002; Green and May, 2005). Stuart D. Green a major critic of 'Lean' has questioned its promotion in a number of his publications by highlighting how the application of Lean practices within construction sector has paid little attention to its implications to human resources allegations in its application within production (Green, 2002; Green and May, 2005).

Green's debate has been seen to be self-consciously and overly critical (Howell and Ballard 1999) and one of his criticisms (Green, 1999) received a direct response from Howell and Ballard (1999). It was argued that 'the respect of people' was inherent in the value of Lean Construction. Lean Construction was also perceived to build up the skills of workers by encouraging active participation of the work force in understanding how work is configured and organised to yield value (Howell and Ballard, 1999).

Lean champions (Ballard, 2000; Ballard *et al.*, 2002; Alarcon *et al.*, 2005) also argue that the negative impacts of Lean Production do not necessarily transfer to lean construction. It was further argued that opposite to Lean Production, some of the techniques used within

construction offers a different solution an example is Just-in-Time system of production which is supposed to eliminate waste by removing buffers. The Last Planner System which is attributed to lean construction uses buffers strategically to reduce workflow variability thereby increasing predictability and plan reliability.

Another popular Lean Construction critique, Winch (2005) questioned the Lauri Koskela's approach for the development of production based theory in construction management. Winch (2006) also criticised the economics based approach in which projects were managed through decomposing elements, costs and transactions as they do not directly address the transformation, flow value perspectives of production that Koskela (1992) stated. Winch (2006) further criticised Lean Construction for basing its concepts on value which is derived from quality management other than the theories of production and that value has been overly simplified.

From the critical comments surrounding 'Lean' in terms of its application within construction, it has been revealed that Lean is maturing as a field within construction management. However, Adrian and Stuart (2011) summarised some of the responses to the criticism and gives the following suggestions on Lean Construction.

1. Lean should be integrated across the entire business and value chains so as to deliver the promised results. Isolated improvements should be avoided as they may even cause more waste.
2. Lean should be implemented carefully and incrementally so it can fully understand how businesses and supply chains work
3. Lean requires disciple and it is more than just a tool or technique.
4. People must be well taken care of, respected, involved and developed.
5. Lean requires a lot of collaboration and thoughtfulness involving the whole system.

3.5. LEAN PRODUCTION TOOLS

Construction The use of specific tools for different purposes promoted the proper implementation of Lean Production by Toyota and other Japanese manufacturers and these tools were consistent with the goals of the Toyota Production System, introduced by (Ohno 1988). The following are some examples of the Lean Production tools: Kanban, Visual Management, First Run Studies, Daily Huddle Meetings, The 5S Process, Just-in-Time, Five-Whys and Kaizen

The Kanban is a tool for controlling the rate, volume and timing of different production elements in an organisation. It essentially uses printed cards to signal the need for more products (Lewis, 2000)

The Visual Management tool is a system that attempts to improve organisational performance by aligning the organisational vision, core values and goals with the work processes and other workplace elements (Hinckley, 2001)

First Run Studies are used to redesign critical assignments by using a `plan, do, check, act' cycle (Ballard and Howell, 1997)

Daily Huddle Meetings is a 2 way communication in order to achieve employee involvement, according (Salem *et al*. 2005).

The 5S Process is a methodology for cleaning and organising the work place. The different 'S'refers to five Japanese words that start with the letter S, denoting five levels of housekeeping that can help in eliminating wasteful use of resources: Seiri (sort) Seiton (straighten or set in order) Seiso (shine) Seiketsu (standardize) and Shitsuke (sustain), (Cheng and Podolosky, 1996).

Five Whys is a tool for identifying the root cause of a problem by repeatedly asking the question `why'. Ohno (1988) indicated that by repeating why five times, the nature of the problem as well as its solution becomes clear".

Kaizen relates to finding and eliminating waste in machinery, labour or production methods (Imai, 1997).

3.6. LEAN CONSTRUCTION TOOLS

Construction processes is usually not automated like manufacturing and each project has a unique physical, environmental and social characteristics. Thus, Koskela *et al.*, (2002) pointed out that the traditional delivery of construction projects focuses on tasks neglecting value maximisation and waste minimisation, however, Lean tools already proven in manufacturing have been adapted to the construction industry with equal success.. The concepts of Lean Construction centres on managing and creating an environment of continuous improvement (Bessant and Caffyn, 1997; Bhuiyan and Baghel 2005) and it empowers people to make positive decisions (Proppendiek and Proppeniek 2003).

Lean Construction is generally defined by the Lean Construction Institute (LCI) as a production management based project delivery system that places emphasis on reliable and speedy delivery of value for the client. Similarly, Adelhamiad and Salem (2005) defined it as a way of designing production systems to minimise the waste of material, time and effort so as to maximise value for the client. Hence, the goal of the concept of Lean Construction is to maximise value, minimise waste and pursue perfection via continuous improvement.

Although it has been argued elsewhere and highlighted in the previous section by Cusumano (1994) that the continuous improvement concepts of Lean has not always been favourable. Koskela however stated that the continuous improvement concept of Lean is derived from the fact that Lean Construction focuses on the pursuit of the three goals of production: transformation, flow and value (TFV) together with the elimination of waste. Waste here is defined as “any inefficiency that results in the use of equipment, materials, labour or capital

in large quantities than those considered necessary in the production of buildings" (Koskela, 1992; Koskela *et al.,* 2002).

Waste is dominant within construction regardless of the kind, location or size of the construction project. However, the principle of Lean Construction aims at minimising if not completely eliminating these wastes (Sowards, 2004). Bhuiyan and Baghel (2005) observed that the implementation of Lean Construction involves developing tools that conform to the core principles of Lean.

Hence, the International Group Lean Construction (IGLC) has led the research on the application of Lean within construction projects using operational tools and techniques that would improve planning; control; supply; visualisation and brings about continuous improvement (Salem *et al*., 2005). Details of these Lean tools and techniques are described and tabulated in Tables 3.2a and 3.2b.

Table 3.2a Lean Implementation tools (source Salam et al 2005; Suresh et al 2010)

SCOPE	TECHNIQUE	DESCRIPPTION	ESSENTIALS	BENEFITS
Flow variability	Last Planner System	Relies on Should-can- will analysis to develop plans and eliminate barriers to flow.	- Reverse phase scheduling - Six week look-ahead - Weekly work plan - PPC CHarts - Pull approach - Quality - Communication & collaboration	- Making work ready to be performed so crew can finish on time without interruption or rework - Managing the project by monitoring the plan's completion rate.
Process improvement	Value stream mapping	Analyse and design flows across processes	- Identify target processes - Draw current state maps, documenting and streamlining the flows - Assess the current state map, highlighting value added and non-value added flows - Draw future state maps - Work towards future state maps	- Creating a learning process by investigating failed plans - Improve designs and construction processes - Reduce direct labour cost
	Error proofing	This involves minimising the defects from occurring	- Visual inspection - Risk assessment - Risk analysis - Teamwork - Check for quality and safety	- Improve performance by reducing the time it takes to perform tasks - Ensure that only competent hands perform sensitive tasks to avoid defects or rework. - Improve quality of each product
	Lean leadership	Systematic application of executive sponsorship techniques	- Organise for success - Promote education - Demonstrate support - TRack accomplishment	- Improve Of the workforce - Build an enthusiastic team - Improve Collaboration between teams

Table 3.2b Lean Implementation tools (source Salam et al 2005; Suresh et al 2010)

SCOPE	TECHNIQUE	DESCRIPPTION	ESSENTIALS	BENEFITS
Transparency	Five 5's	Developed from Japanese words ‘seiso, seiton, seiri, seiketon and shitsuke	- Sort - Straighten - Standardise - Shine - Sustain	- They make the work place conducive in terms of house keeping - The are used for work place design
	Increased visualization	Enhanced communication through signs, labels and media around the work site	- Commitment charts - Safety signs - Mobile signs - Project milestones - Visualization - Communication	- Improving safety by enhancing communication among project participants
Continuous improvement	Kaizen	Entails continuously improving the system	- A planned systematic change process - Suggestion systems - Monitoring results - Adjusting to suit improvements	- Stimulates employees to improve work - Educates employees - Promotes productive work - Reduces cost
	First run studies	This involves studying the work and recognising different functions involved in executing them.	- Plan - Do - Check - Act	- Reduces interruption and prevents errors - Improves the results of planned tasks

3.6.1. LAST PLANNER SYSTEM

Planning and control in Lean Construction is practically achieved through the implementation of the Last Planner System (LPS). LPS has been argued to be the most developed practical use of Lean construction (Alarcon and Calderon, 2003; Thomas *et al.,* 2003). It addresses variability of workflow and reliability of planning, it offers the promise to make assignments ready while supporting short term planning and minimising non-value adding work. It makes projects more predictable, minimises buffers, reduces uncertainties, encourages collaborative planning, creates reliable work plans and decreases workflow variability (Ballard *et al.,* 2009; Gonzalez *et al.,* 2010; Mossman, 2013).

It is a system of production control, introduced in 1992 by Glenn Ballard, which emphasises the relationship between scheduling and production control to improve flow of resources, with the aim of improving productivity by eliminating barriers to workflow (Ballard, 2000; Fewings, 2013). It has been successfully implemented in different developed and emerging countries as shown in Table 3.3

3.6.2. VALUE STREAM MAPPING

This entails documenting and streamlining the flow by analysing a current state map of a construction process, highlighting the value-added and non-value added times together with the lead times. This results in the production of a future state map that depicts or illustrates improvements that can obtained within the process (Arbulu and Tommeline, 2003; Braglia *et al.,* 2006; Yu *et al.,* 2009)

3.6.3. ERROR-PROOFING (POKA-YOKE)

Poka-yoke is a Japanese word for error-proofing which involves all the procedures taken to minimise or prevent defects or errors from occurring on site (Conner, 2001). It is a way of

avoiding inadvertent errors in a way that is simple and cost effective. Hinckley (2001) explained that this tool focuses on improving the performance of a system by reducing the time it takes to perform a task, thereby ensuring that competent hands perform the task to avoid rework, defects and mistakes and also improve the quality of each product.

3.6.4. LEAN LEADERSHIP

Strong leadership is necessary for transformational success within Lean construction. Kotter (1996) noted that it is only through leadership that one can prompt a blast through the many sources of corporate inertia. The author also identified that Lean leadership motivates the actions needed to alter behaviours in a significant way.

Effective leaders have the necessary tools and skills to inspire and impact their teams allowing firms to run competently and smoothly. Lean leadership promotes that a good leader, should understand the vision, mission, objectives, plans and goals of the organisation so as to lead the workforce into realising these same vision mission, objectives, plans and goals. This makes the workforce alert to easily identify errors and correct them through the use of standardised work (Emiliani 2013).

Furthermore, lean leadership ensures the workforce is motivated and enthusiastic to perform their duties while promoting collaboration (Bettler and Lightner, 2013)

3.6.5. FIVE (5) S

This is a work place design tool used in cleaning and arranging a work site in an orderly and coordinated manner, while boosting the productivity and safety of workers (Xu and Zenell, 2005). This is one of the foundations of Lean production management and it was developed from 5 Japanese words (Seiso, Seiton, Seiri, Seiketsu and Shitsuke) translated as (Sort, Straighten, Shine, Standardise and Sustain), although the original meanings are slightly varied. In a nutshell,

5S is known as a Visual Workplace tool that makes the site conducive for the flow of value-adding activities by maintaining everything in its right place (Abdelhamid and Salem, 2005).

3.6.6. INCREASED VISUALISATION

Increased visualisation is a Lean Construction tool that is used to effectively enhance communication by showing in glance key information of a project work in the form of tools, plans, schedules and flow charts, by posting them clearly all around the site. It makes operations and quality requirements clearer using charts, displayed schedules, painted designated inventory and tool locations (Salem *et. al.*, 2005).

3.6.7. KAIZEN

The Oxford English Dictionary defines kaizen as Continuous Improvement. This tool stimulates employees at all level to use their brains to promote a productive work site and reduce cost (Melles, 1997). Kaizen is an approach that facilitates change for the better by focusing on continuous incremental improvement, creating more value and less waste (Imai, 1994).

3.6.8. FIRST RUN STUDIES

First Run Studies are used to plan out and improve critical assignments. It involves studying a critical task or an assignment to be carried out, reviewing the alternative work methods, and identifying and reorganising the different functions involved in executing the assignment, with the best and simplest approach being illustrated to the workers using video files, pictures, or graphical representations (Abdelhamid and Salem, 2005). It involves a `plan, do, check, act' cycle.

3.7. GENERAL OVERVIEW OF THE LAST PLANNER SYSTEM

The Last Planner® system (LPS) was developed by Glenn Ballard and Greg Howell as a Lean Construction tool that encourages planning in greater detail; develops work plans with those who are going to perform the work; identifies and removes work constraints ahead of time as a team to make work ready by increasing the reliability of work plans and making reliable promises. This is achieved by having an active negotiation with trade partners and project participants, so as to facilitate learning from planning failures and finding the root causes of failures and taking preventive actions (Ballard, 2000; Ballard *et al.,* 2007)

The basic function of the LPS thus is to make projects more predictable, minimising buffers, reducing uncertainties, creating reliable work plans, decreasing workflow variability and improving collaborative planning, (Ballard, 2000; Ballard *et al.,* 2009, Gonzalez *et al.,* 2010). The Last Planner allows planners to produce a record of "what *can* be done", from which workers choose tasks – "what *will* be done", while a procedure of system appraisal allows a review of "what *was* done", whereas all the time steps are taken to shield tasks from the effects of dependences with other tasks (Ballard, 2000; Ballard *et al.,* 2007, Ballard *et al.,* 2009).

In a nutshell, the Last Planner is concerned with reducing task workflow and process-time variability, which leads to increase in plan reliability and shortened project duration (Koskela *et al.,* 2010). It operates with buffers in the form of 'workable backlogs' that level the workflow by buffering against unpredicted plan variation (Salem *et al*., 2005). Figure 3.1 below describes this last planner process.

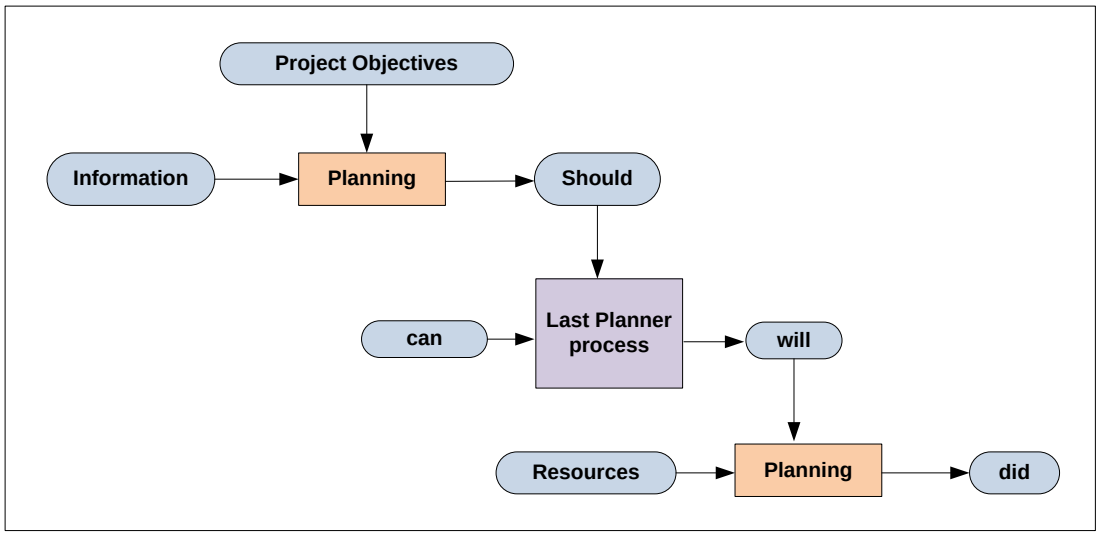


Figure 3.1 The Last Planner Planning Process (Adapted from: Ballad and Howell, 1998)

LPS comprises of five levels of planning processes of: The Master Schedule, Phase Schedule, Look-ahead planning, Weekly work plans and Percentage Plans Completed (PPC). Details of these are explained as sighted in Koskela *et al.,* (2010) Tommelein and Ballard, (1997); Ballard and Howell, (2004); Ballard, (1997); Hamzeh *et al.*, (2008):

3.7.1. THE MASTER SCHEDULE

The master plan is the first phase of the production planning system (Hamzeh *et al*, 2008). Here the objective is to provide an overall view of the project, and to analyse feasibility of project completion (Tommelein and Ballard, 1997). It serves to obtain the collaborative creation of an agreement to, the production sequence. The aim is to bring all the major actors together early in the process, so that critical interdependencies can be discussed, assumptions tested and best practice agreed on (Alsehaimi, 2011). The Preparation of the master plan usually reflects the major project milestones, and these milestone schedules divide the project into logical phases. The duration within these schedules are established in such a manner that those responsible for

the project are confident that the work can be completed as planned (Patel, 2011). The purpose of the master plan is to develop and display execution strategies, demonstrate the feasibility of completing the work within the available time and identify the important milestones to clients or stakeholders (Alsehaimi, 2011).

3.7.2. PHASE SCHEDULE

Phase planning is about dividing the master plan into various phases thus using reverse-phase scheduling – i.e. working backwards from the desired delivery dates; tasks are scheduled in reverse order, allowing them to be performed at the last responsible moment, thus minimising unnecessary accumulation of work in progress (Ahiakwo *et al.*, 2014). It involves developing more detailed work plans and providing goals that can be considered targets to the project team. It also involves a collaborative planning exercise that generates a detailed schedule covering each of the project phases, and identifies handoffs between the various specialty organisations (Alsehaimi, 2011).

The main purpose of a phase schedule is to develop a plan for completing work within a phase of the master plan, so as to produce the best possible plan by involving the representatives of all organisations that work within the phase and to develop a more detailed work plan (Hamzeh, 2009). Within phase Scheduling, the work is done by a cross functional team that will take one of the milestones as a phase, and work backwards identifying the type of work that needed to be done and the conditions required to complete the phase (Ballard and Howell, 2004). Furthermore, phase scheduling involves a face to face conversation that establishes context, define the milestone deliverable, develops an execution strategy, identifies tasks and organises them in a pull plan working from the end of the phase back (Patel, 2011).

3.7.3. LOOK-AHEAD PLANNING

Look-ahead planning states the preconditions that must be evaluated by breaking down activities into the level of processes/operations, so that possible constraints are identified, responsibilities are assigned, and assignments are made, while frantic efforts are made to remove the constraints (Hamzeh, 2011). Any tasks whose constraints have been removed are put on a list called the 'workable backlog'. Look-ahead plans compared to long-term plans, are the outcomes of mid-term planning showing activities initially at the level of processes and subsequently at the level of operations (Hamzeh, 2009).

Ganen, (2012) Further explained that construction generally uses look-ahead schedules to focus supervisors attention on what work is supposed to be done in the near future. The look-ahead plan usually works on a window of 6 weeks (it could be more than the 6 weeks or shorter, depending on the rapidity of the project). When any activity from within this phase plan enters the window the activity is explored in detail and the assignments are subjected to a constraints analysis which determines what must be done in order to make it ready to be done. The assignments in whose constraints are removed and are made ready go into a workable backlog as earlier pointed out. This is a form of assignment inventory, which the Last Planner chooses from to plan their weekly work schedule (Hamzeh, 2011).

Look-ahead planning breaks activities down into the level of processes/operations, identifies constraints, assigns responsibilities, and makes tasks ready by removing constraints (Hamzeh and Bergstrom, 2010). They make tasks ready so that they can be done when the right time comes. Henrich and Koskela, (2005) identified that the main idea behind the look-ahead planning is to reduce uncertainty, identify and eliminate constraints and to achieve the project objectives. Ballard (1997) on the other hand claims that LPS guarantees that whenever production tasks are required they are ready; this helps to reduce waste in time, materials and

equipment while improving the delivery of materials by suppliers and reducing the opportunities for the materials to be damaged prior to installation.

3.7.4. WEEKLY WORK PLANS

Weekly work planning develops the look-ahead plan into a weekly work plan by presenting activities in the most detailed level required to drive the production process (Hamzeh and Bergstrom, 2010). Kalsaas (2012) explained that the Preparation of a weekly work plan is in consultation with the last planner, which involves negotiating with all project team managers in a meeting to achieve a plan that is considered feasible and which has everyone's commitment. This meeting is different from the standard planning meetings for the week ahead in that instead of the management dictating a pre-conceived plan, the team leaders select the tasks to be performed using a strict "can be done" filter in their selection.

Hence, it ensures that only "mature" tasks from the workable backlog in the look-ahead plan are scheduled. Furthermore, this cancels any assignment of tasks that "ought to" be carried out according to the look-ahead, but is susceptible because of unresolved constraints. Thus, weekly work plans contains only tasks that are ready to be performed. This means that all constraints have been removed (Patel, 2011).

The effectiveness of the commitments in the weekly work plans depends on the reliability of the assignments. Hence they need to meet some quality criteria (Koskela *et al.,* 2002): These criteria include – definition, soundness, sequence and size. For each of these criteria to be met, the following questions have to be answered as cited in Ballard (2000).

Definition: Are these assignments specific enough that the right type and amount of information or materials can be collected, can work be coordinated with other disciplines or trades, and is it possible to tell at the end of the week if the assignment has been completed?

Soundness: Are all these assignments workable? Do the work crews understand what is required? Do they have what they need from others, are all materials available? is the design complete and is the prerequisite work complete, etc.?

Sequence: Are the assignments selected from those that are sound in priority order and in order of workability? Will doing these assignments release work needed by someone else? Are there additional quality tasks available in case assignments fail or productivity exceeds expectations?

Size: Are the assignments sized to the productive capability of each individual or crew while still being achievable within the plan period?

3.7.5. PERCENTAGE PLANS COMPLETED

Percentage Plans Completed (PPC): PPC is a measure of the proportion of promises made that are delivered on time. It is calculated in percentage as the number of completed planned activities divided by the total number of planned activities. The aim of PPC is to learn about planning failures and to measures whether the planning system is able to reliably anticipate what will actually be done (Porwal, 2010).

Determining whether an assignment was completed or not according to the plan is mandatory in calculating PPC, but elaborating on reasons for failure to complete the work as planned is even more important (Choo, 2003). PPC is calculated on a weekly basis and these results in identifying the reasons for the disruption of the pace observed in the work while, contributing to organised learning on the jobsite by generating a mindset well geared to improving competitiveness in construction companies (Conte, 2002).

3.8. PREVIOUS APPLICATIONS OF THE LAST PLANNER SYSTEM

There is a substantial body of literature concerning the use of LPS on various construction projects and several case studies of LPS implementation have been documented by the Lean Construction community (and others) in the last two decades. Bortolazza *et al.,* (2006) pointed out that the the Last Planner System has been implemented since 1996 in so many construction sites in Brazil. Similarly, Kemmer *et al.,* (2007) documented an instance where LPS was applied on a 17 story residential building project in Fortaleza, Brazil.

In another instance, LPS was implemented in a commercial construction project, UT Arlington College Park located on the University of Texas at Arlington campus (Patel, 2011). While, Mossman (2013) reported that the largest construction company in Denmark - applied the Last Planner System on more than 25 building projects within two years duration. The author also indicated that LPS was used on the largest project in Europe – the £4.5bn (US$7bn) Heathrow Terminal 5. In the same vein Four case studies were recorded in Denmark (Lindhard and Wandahl, 2013): Case one was a renovation project of 16 three-storey residential apartment blocks, containing a total of 309 flats, Case two was the construction of an educational institution and the project consisted of two buildings in total 11000 m2. The Case three was construction of a nursing home and it consisted of 6 one-storey apartment blocks with a total 68 flats. The fourth case was the refurbishment of a top floor-section at a hospital.

Fiallo and Revelo (2002) studied the benefits of applying LPS on 80,000 square feet, $860,000 residential project in Quito, Ecuador. In their study, the use of LPS resulted in a high level commitment from production units. While in Finland four major companies; YIT Rakennus Oy, Skanska Talonrakennus Oy, NCC Rakennus Oy and Rakennusosakeyhtiö Hartela implemented LPS on four different pilot projects (Koskenvesa and Koskela, 2005). Furthermore, Alsehaimi *et*

al., (2009) examined the effectiveness of implementing LPS to improve the construction planning and control process, in two state-funded construction projects in Saudi Arabia.

In another example, the use of LPS improved communication and coordination among subcontractors on a multi-storey residential construction project (Song *et al.,* 2008). Additionally, the Sutter Health, headquartered in Sacramento, California, implemented LPS on five pilot projects (David Medical Office Building, Modesto 8 Storey Bed Tower, Delta, Roseville Emergency Department, Roseville Parking Structure) as a part of the organisation's Lean initiative in 2004 (Ballard *et al*., 2007). It was however later recorded that after a series of experiments, LPS is now in use in a number of Sutter Health construction projects (Hamzeh, 2009).

Furthermore, Aslesen and Bertelsen (2008) described the use of Last Planner System for production control to improve workflow reliability in a Norwegian shipyard, while Nieto-Morote and Ruz-Vila (2012) recorded the implementation of LPS on a Chemical Plant Construction. Additionally, Alarcon *et al.,* (2008) assessed the impact of LPS implementation across 77 Chilean projects, from 12 companies. These 77 projects included 39 low rise building projects, 15 high-rise building projects, 11 heavy industrial projects and 12 light industrial projects.

Table 3.3 summaries the details of some LPS application in different countries by different authors.

Table 3.3 List of Case Studies (cited in Fernandez-Solis et al. 2013)

s/n	Case project	Country	Reference
1	17-story residential building	Brazil	Kemmer *et al.,* (2007)
2	18 Floor residential building in Sao Paulo, with four control flats	Brazil	Conte, 2002
3	Industrial building for a car manufacturer	Brazil	Sterzi *et al.,* (2007)
4	Construction and refurbishment of an	Brazil	Sterzi *et al.,* (2007)

	industrial building for a car manufacturer		
5	Construction and refurbishment of an industrial building for a steel manufacturer	Brazil	Sterzi *et al.,* (2007)
6	LPS implementation across 77 Chilean projects, from 12 companies.	Chile	Alarcon *et al.,* (2008)
7	A multi-storey residential construction project	China	Song *et al.,* (2008)
8	3 schools in Skelskor: refurbishment and new build	Denmark	Nielsen and Thomassen (2004)
9	Construction of an educational institution. The project consists of two buildings of 11000 m2,	Denmark	Lindhard and Wandahl, (2013)
10	Refurbishment of a top floor-section at a hospital.	Denmark	Lindhard and Wandahl (2013)
11	Construction of a nursing home	Denmark	Lindhard and Wandahl, (2013)
12	Renovation project of 16 three-storey residential apartment blocks, containing a total of 309 flats	Denmark	Lindhard and Wandahl, (2013)
13	Application of LPS on more than 25 building projects	Denmark	Mossman (2013)
14	102 one family units: housing project	Ecuador	Fiallo and Revelo (2002)
15	LPS on four major pilot projects by four different companies	Finland	Koskenvesa and Koskela, (2005)
16	Last Planner System for production control to improve workflow reliability in a Norwegian shipyard	Norway	Aslesen and Bertelsen (2008)
17	7.1 km highway construction	Peru	Olano *et al*., (2009)
18	Leaching pad construction	Peru	Olano *et al*., (2009)
19	Faculty of business and administration building	Saudi Arabia	AlSehaimi *et al.,* (2009)
20	General classrooms and laboratories	Saudi Arabia	AlSehaimi *et al.,* (2009)

21	Seoul subway project	South Korea	Kim *et al.,* (2007); Kim and Jang (2005)
22	Busan subway project	South Korea	Kim *et al.,* (2007); Kim and Jang (2005)
23	Nam Chun Highway project	South Korea	Jang *et al.,* (2007)
24	Seoul Ring Road project	South Korea	Jang *et al.,* (2007)
25	LPS on a Chemical Plant Construction.	Spain	Morote and Ruz-Vila (2012)
26	Industrial bridge construction	Sweden	Simonsson and Emborg (2007)
27	Heathrow Terminal 5 building: civil phase	London, UK	Ballard *et al.* (2007)
28	Haslemere Store Project	UK	Garnet (2001)
29	25£ Million four storey office development	UK	Johansen and Porter (2003)
30	3 miles of carriageway renewal	UK	Ansell *et al.,* (2007)
31	The £4.5bn (US$7bn) Heathrow Terminal 5	UK	Mossman (2013)
32	Air Products: Large chemical plant	California, USA	Ballard *et al*., (2007)
33	New town development	California, USA	Ballard *et al*., (2009)
34	Cathedral Hill Hospital project	California, USA	Hamzeh *et al.,* (2009)
35	Center for Clinical Services Research, Stanford University	Stanford, USA	Ballard (2000)
36	Texas showplace project	Texas, USA	Ballard, (2000)
37	UT Arlington College Park located on the University of Texas at Arlington campus	Texas, USA	Patel, 2011
38	Advanced Communication and Information Technology Center (ACITC) at Virginia Tech	Virginia, USA	Garza and Leong (2000)
39	Four-floor university parking garage	USA	Salem *et al.,* (2005)
40	Pipeline for an oil refinery plant	USA	Liu and Ballard (2009)

The Last Planner System has been successfully implemented in an exhaustive list of projects in different countries around the world. Although, Table 3.3 only recorded 40 case studies of LPS across 13 countries although the there are other cases of LPS implementation in many other countries not captured in the table, for example in China (Gao and Low, 2014), India (Porwal *et al.* 2012), Chile (Alarcon *et al.*, 2008) etc.

On the other hand, the Nigerian Construction industry and other West African countries are yet to fully embrace Lean Construction philosophies and tools (e.g. the Last Planner system) even with the rapid development of Lean Construction and its Last Planner tool, which has received recognition from practitioners all over the world, as a means of effectively improving project planning and yielding other benefits (Gao and Low, 2014; Ballard *et al*., 2009).

3.9. BENEFITS REALISED BY LPS IMPLEMENTATION FROM LITERATURE REVIEWS

Several benefits have been recorded from the implementation of LPS in the case studies presented in Table 3.3. Some of the benefits recorded include: increased work flow reliability, improved supply chain integration, reduced production time, improved communication, improvement in quality of work, improved collaboration, learning among project teams, improved safety, commitment, improved project delivery time and reduced stress. These benefits are tabulated in Table 3.4 and are linked to their corresponding case study.

Table 3.4 Benefits of the LPS

	Benefits of the Last Planner System	**Increased work flow reliability**	**Improved supply chain integration**	**Reduced production time**	**Improved communication**	**Improvement in quality of work**	**Improved collaboration**	**learning among project teams**	**Improved safety**	**Commitment**	**Improved project delivery time**	**Less stress**
1	An 17-story residential building, Brazil (Kemmer *et al.*, 2007)	√		√				√				
2	An 18 Floor residential building in Sao Paulo, with four control flats, Brazil (Conte, 2002)	√			√	√				√		
3	Industrial building for a car manufacturer, Brazil (Sterzi *et al.*, 2007)		√		√							
4	Construction and refurbishment of an industrial building for a car manufacturer, Brazil (Sterzi *et al.*, 2007)		√		√							
5	Construction and refurbishment of an industrial building for a steel manufacturer, Brazil (Sterzi *et al.*, 2007)		√		√							
6	LPS implementation across 77 Chilean projects, from 12 companies, Chile (Alarcon *et al.*, 2008)		√					√		√		
7	A multi-storey residential construction project, China (Song *et al.*, 2008)	√										
8	3 schools in Skelskor: refurbishment and new build, Denmark (Nielsen and Thomassen 2004)		√		√							
9	Construction of an educational institution. The project consists of two buildings of 11000 m2, Denmark (Lindhard and Wandahl, 2013)	√						√				
10	Refurbishment of a top floor-section at a hospital, Denmark (Lindhard and Wandahl, 2013)		√		√			√				
11	Construction of a nursing home, Denmark (Lindhard and Wandahl, 2013)	√	√					√	√			

	Benefits of the Last Planner System	Increased work flow reliability	Improved supply chain integration	Reduced production time	Improved communication	Improvement in quality of work	Improved collaboration	learning among project teams	Improved safety	Commitment	Improved project delivery time	Less stress
12	Renovation project of 16 three-storey residential apartment blocks, containing a total of 309 flats, Denmark (Lindhard and Wandahl, 2013)		√									
13	Application of LPS on more than 25 building projects, Denmark (Mossman 2013)	√				√	√		√		√	√
14	102 one family units: housing project, Ecuador (Fiallo and Revelo 2002)	√								√		
15	LPS on four major pilot projects by four different companies, Finland (Koskenvesa and Koskela, 2005)	√								√		
16	Last Planner System for production control to improve workflow reliability in a Norwegian shipyard, Norway (Aslesen and Bertelsen 2008)	√					√					
17	7.1 km highway construction, Peru (Olano *et al*., (2009)	√						√				
18	Leaching pad construction, Peru (Olano *et al*., (2009)	√						√				
19	Faculty of business and administration building, Saudi Arabia (AlSehaimi *et al.*, 2009)	√				√	√	√			√	
20	General classrooms and laboratories, Saudi Arabia (AlSehaimi *et al.*, 2009)	√				√	√	√			√	
21	Seoul subway project, South Korea (Kim *et al.*, 2007; Kim and Jang 2005)	√		√					√			√
22	Busan subway project, South Korea (Kim *et al.*, 2007; Kim and Jang 2005)	√		√					√			√
23	Nam Chun Highway project, South Korea (Jang *et al.*, 2007)	√		√					√			√
24	Seoul Ring Road project, South Korea (Jang *et al.*, 2007)			√					√			
25	LPS on a Chemical Plant Construction, Spain (Morote and Ruz-Vila 2012)						√	√		√		

	Benefits of the Last Planner System	Increased work flow reliability	Improved supply chain integration	Reduced production time	Improved communication	Improvement in quality of work	Improved collaboration	learning among project teams	Improved safety	Commitment	Improved project delivery time	Less stress
26	Industrial bridge construction, Sweden (Simonsson and Emborg 2007)											√
27	London Heathrow Terminal 5 building: civil phase, UK (Ballard *et al.* 2007)			√			√	√			√	
28	Haslemere Store Project, UK (Garnet 2001)	√		√		√						
29	£25 Million four storey office development, UK (Johansen and Porter 2003)	√					√					
30	3 miles of carriageway renewal, UK (Ansell *et al.*, 2007)			√			√	√			√	√
31	The £4.5bn (US$7bn) Heathrow Terminal 5, UK (Mossman 2013)					√					√	
32	Air Products: Large chemical plant, California, USA (Ballard *et al*., 2007)			√							√	
33	New town development, California, USA (Ballard *et al*., 2009)			√							√	√
34	Cathedral Hill Hospital project, USA (Ballard *et al*., 2009)				√			√	√			
35	Center for Clinical Services Research, Stanford University, USA Ballard (2000)	√							√			
36	Texas showplace project, USA Ballard (2000)	√										
37	UT Arlington College Park located on the University of Texas at Arlington campus, Texas USA (Patel, 2011)	√				√	√					
38	Advanced Communication and Information Technology Center (ACITC) at Virginia Tech, USA (Garza and Leong 2000)	√						√				
39	Four-floor university parking garage, USA (Salem *et al.*, 2005)	√				√						
40	Pipeline for an oil refinery plant, USA (Liu and Ballard, 2009)	√						√				

3.10. LAST PLANNER SYSTEM IMPLEMENTATION CHALLENGES

In addition to the benefits recorded in Table 3.4, different challenges faced by construction professionals during the LPS implementation processes have also been recorded by different authors (Garza and Leong, 2000; Alarcón *et al.*, 2005; Ansell *et al.*, 2007; Ballard *et al.*, 2007; Kemmer *et al.*, 2007; AlSehaimi *et al*., 2009; Hamzeh *et al*., 2009). These barriers if not managed properly could affect the application process and hinder the project performance.

Based on a careful and comprehensive literature review relating to the barriers to implementing the LPS, the following barriers were identified as sighted in (Ballard, 2000; Garza and Leong, 2000; Kim and Jang, 2005; Salem *et al.*, 2005; Bortolazza *et al.*, 2006; Salem and Solomon 2006; Kim *et al.*, 2007; Ballard *et al.*, 2009; Alsehaimi *et al*., 2009; Hamzeh *et al*. 2009; Gonzalez *et al.*, 2010; Alsehaimi, 2011). These barriers included: lack of commitment, lack of ability to work in group, political factors, lack of commitment to the LPS implementation, lack of top management support, incompetent project managers, lack of experience on Lean and LPS, lack of skilled and professional workers, lack of government control and enforcement, unethical practices, traditional procurement methods, short-term vision, organizational resistance, partial or late implementation of LPS, unclear strategic goals, fragmentation and poor contracting or legal issues, lack of stakeholders support, delay from suppliers and subcontractors, short-term vision, lack of collaboration, bad work ethics and cultural issues.

Conversely, this study classifies these barriers into six major groups of barriers on the basis that the different list of barriers identified from literature reviews are the root causes to these six major barriers. These barriers are related to the same six major challenges affecting the Nigerian

construction industry. They include: cultural issues, lengthy approvals, resistance to change, subcontractors involvement, poor supervision and quality control, fluctuation and variation.

Table 3.5 Classification of challenges of LPS into six major categories

S/N	Six major group of challenges	Perceived root causes of challenges from previous research
1	Cultural issues	Lack of commitment to the LPS implementation, lack of experience on Lean and LPS, unethical practices, lack of commitment, lack of ability to work in group, partial or late implementation of LPS and bad work ethics.
2	Lengthy approvals	Lack of government control and enforcement, traditional procurement methods
3	Resistance to change	Lack of top management support, short-term vision, organizational resistance, unclear strategic goals.
4	Lack of Subcontractors involvement	Fragmentation and poor contracting or legal issues, delay from suppliers and subcontractors, lack of collaboration.
5	Poor supervision and quality control	Incompetent project managers, lack of skilled and professional workers.
6	Fluctuation and variation	Political factors, lack of stakeholders support, inflation, inadequate funding of projects, unstable markets for construction

3.10.1. CULTURAL ISSUES

Ankrah (2007) in looking at the different orientations of culture in relation to project performance identified that different dimensions of culture was significantly associated with project performance outcomes. Lean thinking on the other hand requires employees to change the way they execute their work (Liker, 2004). This is often seen as a cumbersome task and in most cases threatening for construction workers to change their status-quo from a somewhat

dysfunctional system which they have operated relatively successfully to a new system. However, changing old traditions and behavior is a necessary prerequisite for implementing Lean Construction tools especially the LPS (Olatunji, 2008, Abdullah *et al.*, 2009, and Mossman, 2009).

Based on the classification of linear causality criteria stated in table 3.4, the perceived root causes of cultural issues include: lack of commitment to the LPS implementation, lack of experience on Lean and LPS, unethical practices, partial or late implementation of LPS, bad work ethics, lack of commitment, lack of ability to work in group (Ballard, 2000; Garza and Leong, 2000; Kim and Jang, 2005; Salem *et al.*, 2005; Bortolazza *et al.*, 2006; Salem and Solomon 2006; Kim *et al.*, 2007; Ballard *et al.*, 2009; Alsehaimi *et al*., 2009; Hamzeh *et al*., 2009; Gonzalez *et al.*, 2010; Alsehaimi, 2011)

3.10.2. RESISTANCE TO CHANGE

The successful implementation of Lean Construction and the LPS requires the support of the organisation and the top management (Sarhan and Fox, 2013). Bashir *et al.*, (2010) indicated that it is usually the top managers that provide sufficient resources, time and commitment to develop plans that will sustain and manage changes that occur from the implementation process. Table 3.4 clearly shows that from the perceived root causes from the linear causality criteria; lack of top management support, short-term vision, organizational resistance, unclear strategic goals are the perceived root causes of the resistance to change.

3.10.3. LENGTHY APPROVALS

The successful implementation of Lean Construction and LPS requires a fast approval of orders free from delays as this can create unnecessary bottle necks that in turn will negatively impact on project durations (Bashir *et al.*, 2010). Similarly Olatunji (2008), identified that lack of

government control and enforcement, can adversely affect the approval processes within the construction industry. In the same vein the traditional procurement methods involves a lot of bottlenecks which result in lengthy approval of orders (USAID, 2013). Similarly, in traditional contractual procedures, the design and implementation of project are treated as separate entities (Rooke *et al.*, 2007). This causes a conflict border between the two phases and creates lots of waste generating a lot of variation from values specified in the design which cannot be constructed or design changes made by designers (Shammas-Toma *et al.*, 1998; Rooke *et al.*, 2007).

3.10.4. FLUCTUATION AND VARIATION

Fluctuation and variation serve as major barrier to LPS implementation. Dulaimi and Tanamas (2001) indicated that for the successful implementation of Lean Construction and LPS, some common financial barriers that need to be carefully addressed. These include: lack of stakeholders support, inflation, inadequate funding of projects and unstable markets for construction. Additionally, Bashir *et al.*, (2010) recognised that political instability could cause fluctuations and pose barriers to the successful implementation of Lean Construction tools.

3.10.5. LACK OF SUBCONTRACTOR'S INVOLVEMENT

Adversarial relations between contractor and subcontractors tend to undermine the application of Lean techniques within construction projects (Sarhan and Fox, 2013). Similarly, fragmentation and poor contracting or legal issues, delay from suppliers and subcontractors and lack of collaboration are grouped as the perceived root causes to lack of subcontractors involvement. These adversarial relationships create transaction costs, delays and stoppages. These are all considered as 'waste' thus opposing the notion of Lean Thinking (Mossman, 2013). Johansen

and Walter (2007) added, stating that fragmentation separates the design from the construction process; and therefore misses the Lean aim of collaboration and integration.

3.10.6. POOR SUPERVISION AND QUALITY CONTROL

The implementation of any new process requires skilled and professional workers to drive the change process. However, poor supervision and quality control issues hamper the application of Lean construction (Bashir *et al.*, 2010). Several studies, (Sarhan and Fox, 2013; Fernandez-Solis *et al., 2013*) indicated that the root causes of poor supervision and quality control issues are management related and they include: incompetent project managers, lack of skilled and professional workers, poor planning, logistics' problems, absence of look-ahead planning and poor coordination.

3.11. CHAPTER SUMMARY

This chapter has examined the concept of lean construction and its evolution. It further reviews critiques to Lean. The chapter also reviewed some Lean Construction tools with particular emphasis on the Last Planner System. The Last Planner System was closely examined together with a review on its previous applications within different case studies. The chapter identified 35 case studies of LPS across 11 countries discussing the benefits recorded from these cases which include: high level of commitment on the part of the production units; increased work flow reliability; reduction of the expected construction time and production costs; improved supply chain integration and improved communication among project participants; improved the quality of work practice at construction site and enhanced managerial practices in construction projects; increased learning among project teams; reduced stress levels at construction sites; less firefighting or fewer day-to-day; improvements in plan reliability, project delivery time, labor productivity, safety, and quality.

In the same vein, the chapter also identified LPS challenges from the 35 case projects and classified them into six different categories using the criteria of linear causality. These challenges include: cultural issues, lengthy approvals, resistance to change, subcontractors involvement, poor supervision and quality control, fluctuation and variation.

Empirical evidence is therefore required to verify if similar challenges will be recorded while implementing the Last Planner System in Nigeria. Hence the next chapter covers details of the research methodology i.e. Design Science Research, adopted in this research. It will examine how the Last Planner System can be practically implemented in construction projects in Nigeria using action research.

4. Chapter Four - RESEARCH METHODOLGY

4.1. INTRODUCTION

Having reviewed the relevant literature for the research in the previous chapters, it is now imperative to demonstrate the philosophical principles behind the research and how it was designed to address its objectives. This chapter thus describes the methodology used in carrying out this research. It introduces Design Science Research (DSR) methods and further justifies the adoption of this research method employed to meet the objectives of this research. Design science research approach is introduced as an alternative approach to the traditional research methods employed within construction management. This chapter also discusses the data collection and evaluation processes utilised in carrying out this research.

4.2. RESEARCH METHODS

Research is defined in the Oxford English Dictionary (1996) as the investigation and study of materials so as to establish facts or reach logical conclusion. Similarly, Herbert (1990) defined research as the process of seeking using different methodological enquiries solution to problems, while adding to the body of knowledge in discovering significant insight.

Methodology on the other hand is defined as a set of techniques or procedure used to inquire into a matter (Easterby - Smith *et al.*, 2002). Combining both words (i.e. Research methodology), Corbin and Strauss, (2008) describes research methodology within a doctoral research as a practice rooted in how knowledge is created and the philosophy that underpins how the research is carried out. Hence, as observed in Herbert (1990) in carrying out any form of research, it is imperative to first define the reason for conducting the research so as to define the research method. Similarly, Crotty, (1998) defined ‘Methods’ as the techniques or procedures used to gather

and analyse data related to research questions or hypotheses. Consequently the research question for this study which is the reason for conducting this research is:

> *Can Lean Construction tool; the Last Planner System, be successfully implemented to improve construction processes within Nigeria?*

4.2.1. RESEARCH DESIGN

The Research design is the program that guides the investigator in the process of carrying out the research in terms of collecting, analysing and interpreting data (Yin, 1994).

The research question already stated above in the previous section is the first step in the research design (Herbert, 1990; Gill and Johnson, 1991). Barnes (1995) concurs to this, affirming that each individual researcher approaches a research question with a different perspective and uses different methods to answer their questions. Hence Coolican (1996) advices that researchers should understand the reasons behind the choice of their research design.

This research project employs a Design Science approach to address this research question. Design Science Research (DSR) is often presented as a relatively new research approach. However, it has been utilised since the 1990s in accounting and information systems (Lukka 2000; Hervner *et al* 2004) while as a management research since 2000 (van Aken 2004).

Hence, the next section discusses its historical development, philosophies and justifies its appropriateness for this particular project.

4.2.2. HISTORY OF DESIGN SCIENCE RESEARCH

Historically, Design Science Research (DSR) has been traced to the study of Herbert Simeon in 1996 ‘Science of the artificial’ (Simeon, 1996). Although Hervner *et al.*, (2004) and March and Storey (2008) argue that humans have been unknowingly undertaking Design Science related activities.

DSR is predominantly utilised in information systems discipline (Hervner *et al.,* 2004). It has its roots in engineering and other applied sciences (Venable, 2008). It is a research method used in solving problems faced in real world by producing an innovative construction that can make contribution to theory in the area where it is applied (Lukka, 2003).

The ultimate goal of DSR is to produce scientific knowledge by developing scientifically grounded solutions that links theory and practices while solving real world problems (Formoso *et al*., 2012). In the same vein, Vaishnavi and Kuechler (2007) reveal that in DSR, knowledge is produced during the research process and this knowledge strengthens the relevance of an academic research.

Generally, in any scientific research, any scientific claim is empirically tested (March and Smith, 1995). Hence, Van Aken (2004) distinguished science into three major categories.

1. Formal
2. Explanatory
3. Design Science

The formal science category refers to mathematics, physics etc and within this category, knowledge is built by creating abstraction proposals and testing their logical consistency (Van Aken, 2004).

Explanatory science on the other hand is a science where knowledge is explained, described or predicted based on observed phenomena (Van Aken, 2004).

While in Design Science, knowledge is produced through creating and implementing a solution that can change a particular phenomenon (Varshnavi and Kuechler, 2007).

Generally, Design Science Research is a research approach for conducting research in Lean Construction (Formoso *et al.,* 2012). In addition, Koskela (2008) states that to help solve the

problem of relevance affecting construction management as a discipline, other than carrying out explanatory studies in the form of explanatory science, such studies should be positioned as a design science research. Similarly, Alshehamni *et al* (2009) and Simeon (1996) points out that in order to connect research and practice while producing theoretical knowledge, research should be positioned as design science. In view of these, in carrying out this research project, DSR is chosen as the research approach. The succeeding section highlights the processes involves in carrying out DSR.

4.2.3. PROCESSES OF DESIGN SCIENCE RESEARCH

Design Science Research (DSR), by definition involves the development of a solution with practical and theoretical relevance (Brady *et al.*, 2012). Hence the process involves designing and constructing. However, Pfeffers *et al*., (2007) identified that DSR involves designing and constructing an artefact that can be utilised in solving practical problems. The same author identified four key processes of carrying out DSR.

1. Identification of a problem and motivation
2. Definition of objectives for the solution
3. Design and development
4. Demonstration
5. Evaluation
6. Communication

However, previous work has identified the different processes of DSR this is highlighted in Table 4.1. This research adopts a process similar to the process in Lukka (2003) also depicted in

the Table 4.1; which states: *identify a problem, access the problem, understand the problem, innovate a solution, implement a solution, identify and analyse theoretical contributions*.

Similarly, this research *identifies a problem*; i.e. the current condition of the Nigerian construction industry; *accesses the problem*; i.e. via literature reviews. The research further *understands the problem*; by identifying the key causes and effects of the problems affecting the Nigerian construction industry. This research groups these key problems into six categories and they include: lengthy approval, cultural issues, fluctuation and variation, supervision and quality control, subcontractor's involvement and resistance to change.

Furthermore, *a solution is proposed*, i.e. the Last Planner System to improve the workflow reliability, planning and control of construction projects. This last Planner System is then implemented to test if it can bring about positive improvements to the quality performances of the Nigerian construction sector.

The outcome of the implementation is identified and analysed, with the contribution to knowledge both in practise and theory discovered.

Table 4.1Comparison of design science processes (Offerman et al., 2009)

Processes	Pfeffers *et al* (2008)	Takeda et al (1990)	March and Smith (1995)	Vaishnavi and Keuchler (2005)	Lukka (2003)
PROBLEM IDENTIFICATION	-Problem identification & motivation -Define the objectives for the solution	-Enumeration of problems		-Awareness of problem	-Identify a problem -Access the problem -Understand the problem
SOLUTION DESIGN	-Design and development	-Suggestion -Development	-Build	-Suggestion -Development	- Innovate a solution -Implement the solution
EVALUATION	-Demonstration -Evaluation Communication	-Evaluation to confirm the solution -Decision on solution to be adopted	-Evaluate	-Evaluation -Conclusion	-Identify and analyse theoretical contribution

4.2.4. OUTCOMES OF DESIGN SCIENCE RESEARCH

Listed below are some of the outcomes of DSR.

1. An Artefact (Hervner *et al.,* 2004)
2. Better theories (Vaishnavi and Kuechler, 2007)
3. Technological rule (van Aken, 2004)

1. An Artefact

Hervener *et al* (2004) described the outcome of an artefact in DSR to entail the design of the artefact, together with the construction and evaluation of the artefact. The outcome of an artefact is grouped into four outputs (March and Smith, 1995).

1. Constructs or concepts

2. Models
3. Methods
4. Instantiations

Constructs or concepts – these constitute the conceptualisation that describe the problem while specifying possible solutions. They mainly form the vocabulary of the domain for the research (March and Smith, 2004).

Models – these represent a group of propositions that express relationships amongst constructs. They are viewed as a description or representation of how things are. Natural scientists refer to Models as theories (March and Smith, 2004). However, Vaishnavi and Kuechler (2007) argue that models differ from natural science because natural science focuses on truth while Design Science primarily focuses on utility. The author identified that a model is described by what it does, while theories are extrapolated and expressed in theoretical statements of how and why outputs occur.

Methods – this is a set of rule for executing a task (March and Smith 1995). Methods are goal directed plans used for manipulating constructs so the solution statement model is realised (Vaishnavi and Kuechler, 2007).

Instantiation – this is described by March and Smith (1995) as the realisation of the artefact. They describe the feasibility and effectiveness of the constructs, models and methods.

2. Better theories

DSR creates better theories as an outcome of the research process by building solutions that test a particular body of knowledge (Vaishnavi and Kuechler, 2007). Within the field of natural sciences, this plays the role of experiments. It was also identified by Vaishnavi and Kuechler (2007) that DSR contributes to better theories in two different ways.

1. The construction of the artefact as an object of theorizing. This can be an experimental proof that a method works.
2. The artefact exposes the relationships that exist within its elements.

3. Technological rule

Van Aken (2004) proposes that in DSR, a technological rule is a type of outcome because it acts as a prescription for a class of problem, linking a solution to a particular goal. Technological rule usually involve the statement of a goal and prescription for the problem by justifying why a rule is able to achieve a particular goal.

4.2.5. CONTRIBUTION TO KNOWLEDGE WITHIN DESIGN SCIENCE RESEARCH

As identified in Hervner *et al.,* (2004), within DSR the contribution to knowledge is related to the following:

1. The design artefact: this serves as a contribution to knowledge in terms of how the design artefacts serve as solutions to unsolved problems.
2. The foundation: the contribution to knowledge for the foundation is in terms of the knowledge base in the domain.
3. The DSR methodology: DSR in itself is an innovative research method; hence it serves as a contribution to knowledge in whatever fields it is applied.
4. The use of an existing solution in a new domain. DSR seeks to produce a solution to solve a practical problem. However if an existing solution is used in a new domain, this serves as a contribution to knowledge.

In addition to the contribution of knowledge of DSR are the outcomes it produces

4.2.6. PHILOSOPHIES OF DESIGN SCIENCE RESEARCH

Creating any substantive theory requires thoroughly understanding the theoretical solutions associated with the theory (Holmstrom *et al.,* 2009). Hence this section discusses the philosophies underpinning DSR.

Research generally is underpinned by the understanding and perspective of the research philosophies. Table 4.2, presents a review of philosophical assumptions of three different research perspectives.

Table 4.2 Research perspectives according to Vaishnavi and Kuechler (2007)

Basic Belief	**Positivist**	**Interpretive**	**Design**
Ontology	A single reality, knowledgeable and probabilistic	Multiple realities, socially constructed	Multiple, contextually situated, alternative world state, socio-technologically enabled
Epistemology	Objective, dispassionate, detached observer of truth	Subjective i.e. values and knowledge emerge from the research participant interaction	Knowing through making objective constrained construction, within a context. Iterative circumscription
Axiology: what is of value	Truth: universal and beautiful. Predictive	Understanding: situated and descriptive	Control, creation, progress, understanding

The philosophical implication of any research project is very important to any PhD project. This is because it enables the researcher to reflect on the entire premises on which the research method is basing its assumption (Remenyi *et al.,* 1998). DSR by its definition changes the world through the introduction of novel artefacts (Simeon, 1996). Hence Vaishnavi and Kuechler

(2007) identified that the philosophical perspective of DSR changes as progress is iteratively made, through the entire research process.

Ontology is the study of the nature of reality. It distinguishes what is real from what is not. However, DSR deals with alternative or multiple world states which differs from ontology that deals with a composite unit of analysis (Vaishnavi and Kuechler, 2007).

On the other hand, epistemologically thinking, DSR is pragmatic in nature (Pierce, 1931). This is because there is a flow of information throughout and iteration process. Hence the dependency on predictable artefacts gives DSR an epistemology that is similar to that of natural science research (Vaishnavi and Kuechler, 2007).

Axiology is the study of value. Within DSR, the researcher takes a positivist stance and values creative manipulation and control of his environment.

DSR undergoes a cyclic process by creating reality through constructive interventions while reflecting or observing on the system and comparing it to the predictive theory proposed during the inception of the research (Vaishnavi and Kuechler, 2007). The major difference between traditional research and DSR is that one is description driven while the other prescriptive. Table 4.3 from Van Aken (2004) illustrates these differences.

Table 4.3 Differences between descriptive and prescriptive research

Characteristics	Description driven i.e. traditional research	Prescriptive driven i.e. DSR
Dominant paradigm	Explanatory science	Design science
Focus	Problem focused	Solution focused
Logic	Hindsight	Intervention
Typical research question	Explanation	Alternative solution for a class of problem
Typical research product	Causal model; quantitative law	Tested and grounded technological rule
Justification	Proof	Saturated evidence
Type of resulting theory	Organisation theory	Management theory

4.2.7. JUSTIFICATION OF DESIGN SCIENCE RESEARCH

DSR is undertaken by people who are trying to address problems inherent in an organisation (Hevner *et al.,* 2004). Although Iivari (2007) criticised DSR arguing that DSR needs to go beyond innovative design artefacts and be grounded in better theories. Hevner, (2007) on the other hand countered the argument, by illustrating the rigor and relevance of DSR using three closely interrelated cycles; Relevance, rigor and design. These cycles function as key performance indicators of DSR.

Consequently, Formoso *et al.,* (2012) identified that it is a useful research method in the development and implementation of innovative managerial tools. These tools are used in tracking different managerial problems in the field of construction and should be specifically utilised within Lean Construction research (Formoso *et al.,* 2012).

This research which its central theme is on the application of a Lean Construction tool in Nigeria, adopted the Last Planner System (LPS) as the Lean Construction tool to improve project planning within construction processes in Nigeria. Hence in this research, three case studies were reported; two of these cases describe how LPS is successfully implemented as an example of a solution to the planning and control problems encountered in Nigeria construction processes. Hence DSR approach was chosen, since the aim of the research is consistent with the aim of DSR approach; which is to develop or utilise a solution that solves practical problems while providing theoretical contribution to knowledge (Alsehamini *et al.,* 2011).

4.3. RESEARCH STRATEGY

A research strategy dictates the major direction of the research and constitutes one of the important decisions made by the researcher (Pathirage *et al.,* 2008). Marshall and Rossman

(1999) state that a research strategy consists of the overall rationale; site selection; population selection (or both); the researcher's role; data collection methods; data management; data analysis strategy; trustworthiness features; and, a management plan. The choice of an appropriate research approach not only reflects the nature of the study but the research objectives as well. There is a wide range of research strategies such as experiments, action research, ethnography, case study, grounded theory and so on.

However, the strategy adopted for this DSR is an action research. An action research (AR) is an established qualitative research method used for scholarly investigation (Azah *et al.*, 2010). Kurt Lewin (1946) was the first to use the concept of an action research in a qualitative study. It combines theory and practice, the researcher and practitioner, an intervention and reflection. It achieves these by reviewing an existing problematic situation, getting involved within the process and initiating some changes to improve the situation (Azah *et al.*, 2010).

An action research generally provides an opportunity for researchers to study complex phenomena within their contexts (Baxter and Jack, 2008). Action research is usually carried out within a five phase cyclical process of: diagnosing, action planning, action taking, evaluating and specifying learning.

Step 1: Diagnosing: This entails analysing the current situation to identify all the problems that can be derived. It also involves holistically interpreting complex research problems that lead to the development of theoretical assumptions (Baskerville, 1999; Jang *et al.*, 2011).

Step 2: Action planning: This involves setting up plans based on the theoretical assumptions identified. In this phase, the researcher and practitioners collaborate, specifying the actions that would improve the problems identified (Azah *et al.*, 2010).

Step 3: Action taking: The planned action is implemented with a collaboration of the research and practitioners. These actions result in changes within the organisation (in which the intervention is carried out) (Baskerville, 1999; Azah *et al*, 2010).

Step 4: Evaluating: The researcher and practitioner critically assess the outcome of implementing the plan. This includes examining the theoretical effects of executing the plan (Azah *et al*, 2010). Where the effects reveal it was unsuccessful, another iteration of action research cycle is established with the hypothesis modified (Baskerville, 1999; Jang *et al.*, 2011).

Step 5: Specifying learning: This is usually an ongoing process. The accumulated knowledge gained from the action research is directed to three audiences as demonstrated in Azah *et al.*, (2010). These audiences include:

1. The organisation where the research was carried out. It serves as the target of the research, with the research restructuring it during and after the whole research process. Where positive results are recorded, it serves to bring about noticeable changes there.
2. Where the results are negative, and the planned change unsuccessful, it provides a foundation for further research.
3. The scientific community gains from either the success or failure of the theoretical propositions put forward within the iteration. The results produce knowledge for future research within the subject matter for the scientific community.

In view of these five circulatory steps discussed above, figure 4.1 illustrates how this design science research is conducted using an action research and reported using case studies.

Case studies are used in any action research to report details of the research carried out. They are used to empirically investigate any contemporary phenomenon, within its real life context using multiple sources of evidence (Robson, 1993). Case study reports are usually substantive (Lincoln

and Guba, 1985) and is concerned with the problem description, illustrations of the context, the transactions or events that took place, the salient themes that emerged and finally the outcomes or lessons learnt.

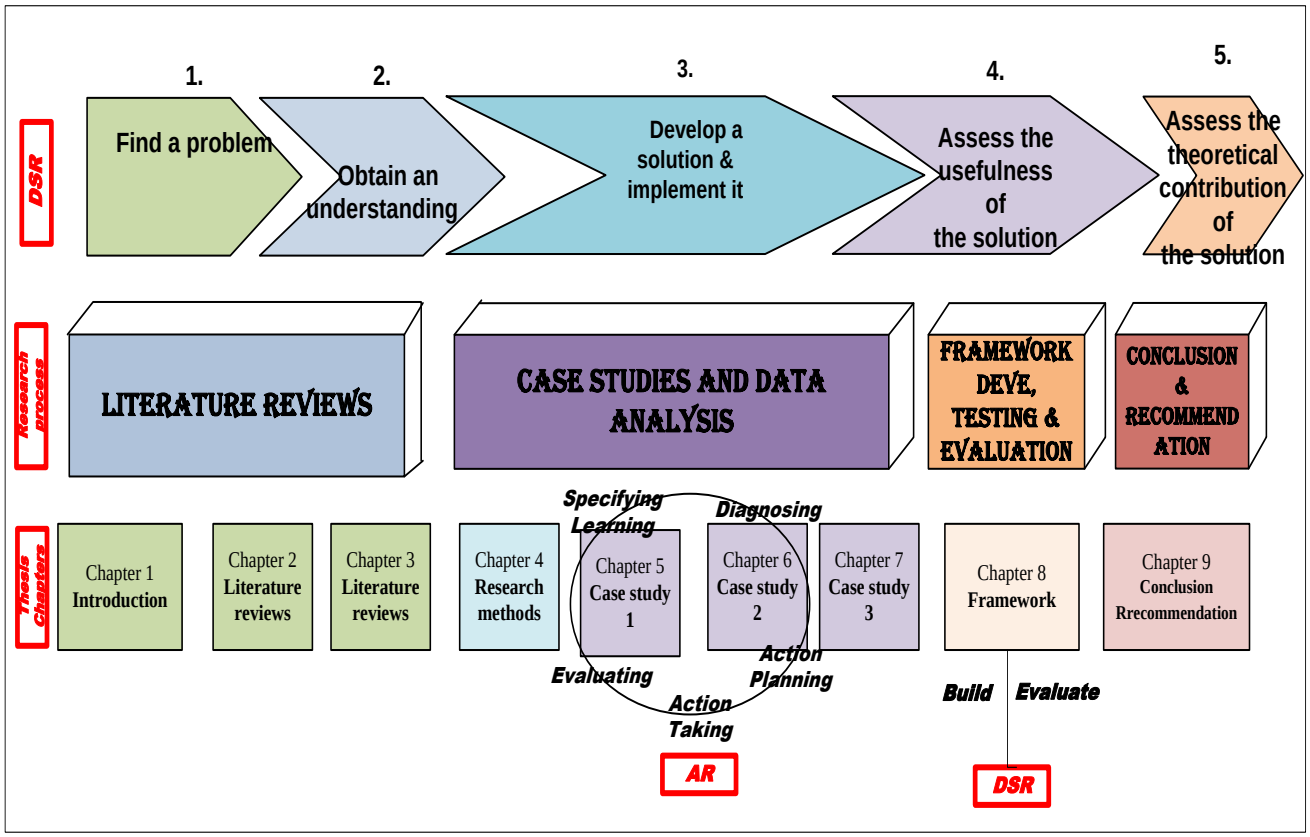


Figure 4.1 The Research Process

4.3.1. CHALLENGES OF CARRYING OUT THIS RESEARCH

Action Research actively engages the researcher to develop a new solution that has the potential of altering existing practice, while testing the feasibility of the solution (Kaplan, 1998). Hence in carrying out this research, the researcher played the role of a change facilitator. This is a difficult role, as the researcher has to strike the balance between being actively involved in the project or allowing the project process to occur naturally.

In addition, Action research is personally time consuming, demanding and challenging as well as makes the researcher worried and concerned with managing the conflicts that might arise in the course of the project. This is because the researcher is an active participant on the project and with a sense of responsibility to the project.

These challenges arise from the inherent characteristics of an Action Research process; Lukas (2008) classified these characteristics as the key features of an AR. They include:

- Rigorous testing of theories in a natural organisation setting.
- Implementing an innovation while tailoring it to meet local needs; and reflecting on the system being changed.
- Collaboration of the researcher and the organisation.

4.4. DATA COLLECTION METHODS

DSR focuses on the development (construction) of a solution and its evaluation (Hevner *et al.*, 2004). It allows for multiple data collection tools rather than a single method of data collection. Hence, multiple sources of data collection were employed in this research. It included: interview, focus groups, participant and non-participant observation, survey questionnaires and documentary analysis. The data was evaluated based on the utility, quality and efficacy of the information gathered.

In Yin (2003), it was reported that utilising multiple sources of evidence helps clarify the real meaning of the phenomena. Hence, this research relies on multiple sources of data collection. The data was from both secondary and primary sources.

For the secondary data, literature was reviewed in order to build a theoretical base for the study. The literature search served as the starting point of the DSR process. Here the problem was identified and more understanding on solving related problems were developed. Lean

Construction concepts and techniques were reviewed and an in-depth literature review of the Nigerian construction industry was undertaken. This was to identify the inherent and peculiar problems facing the industry, this lead to the sourcing of primary data to better understand the problem from a theoretical and practical perspective.

Primary data collection entailed observations and documentary analysis; interview and survey questionnaires.

The primary data was reported in three case study projects and details of the data collection methods are discussed in the proceeding subsections.

4.4.1. OBSERVATION AND DOCUMENTARY ANALYSIS

The observations entailed both participant and non-participant observation. During the non-participant observation which occurred before the LPS implementation, the researcher observed the way site activities were planned and controlled, without any actual interaction with the project participants. It constituted the main pillar for the data collection. The non-participant observation was noted to be an important process of an action research (deMunck and Sobo, 1998) as the researcher was expected to capture what would likely not have been explicitly recorded in any documentation. Although, Yin (1994) argues that there is the risk of the presence of the researcher influencing the events being monitored. However, it is not unusual to have students both interns and researchers observing and recording site activities.

On the other hand, the participant observation which occurred during the implementation entailed the researcher serving as a facilitator within each of the case studies. The researcher defined and organised the implementation strategy and this required interacting with the field operatives by attending weekly meetings where weekly work plans were discussed, PPC calculated and look ahead and phase planning reviewed. During the participant observations, in

combination with the data gathered from the non-participant observation, the researcher was able to understand the culture, behaviour and intentions of the project participants. Especially during unscheduled events that occurred during the implementation.

DeWalt and DeWalt (2002), however claims that participant observations is usually conducted by a biased human who serves as the instrument for data collection. To alleviate this problem, Schensul, *et al* (1999) suggests the use of systematic observation procedures which incorporates rigorous sampling and recording techniques that involves a complete immersion of the researcher among the research participants. Similarly, in carrying out this research, the researcher immersed himself completely into the case projects and put his construction experience to use while making an accurate observation of the construction processes without imposing preconceived categories on the research theoretical perspective.

The documentary analysis was also complementary to the participant observation process. The researcher was involved in reviewing planning documents, drawings, designs, monthly progress reports, tender documents, meeting minutes, weekly work plans and other correspondences. However, the access to these project documents and materials varied from one case study to the other. The information gathered from these documentary analyses were used to obtain an overview and case history of the individual projects.

4.4.2. INTERVIEWS

The interviews were an opportunity to draw on the knowledge of the practitioners without posing a bias as people were able to talk about something in detail and in-depth. This is because most times emotions and feeling are difficult to be seen (Serpell and Rodriguez, 2002). A semi structured interview was carried out within the three case studies. Using semi structured interviews was more flexible and allowed the exploration of emergent themes and ideas.

Furthermore, the problem of the researcher predetermining what will or will not be discussed during the interview was resolved.

The interview was designed using standard best practice guidelines (Serpell and Rodriguez, 2002) and the interviewee targets were the experienced key project participants. Additionally, the interviews followed a basic structure of open ended questions formats and schedules, which served as the interview guide as shown in Appendix 2A, 2B and 4.

4.4.3. QUESTIONNAIRE

Questionnaires surveys were utilized at the tail end of the implementation. Even though there were no LPS implementations in the third case study. However, questionnaires were still used within the case study. The questionnaire was to provide a feedback on the implementation process. The questionnaire was divided into four sections. The first two sections were to establish the profile of the respondents and that of his organisation. Subsequently, the next section reviewed the benefits recorded in the implementation of LPS while the last section dwelt with the critical success factors of the implementation.

The questions for the first two case studies focused on the barriers, benefits and critical success factors of the implementation. However, the questionnaires for the third case study focused on the performance of the project in relation to the current construction practices of the project.

4.4.4. QUESTIONNAIRE DESIGN AND ANALYSIS

Properly designing and formatting questionnaires plays a huge role in achieving a high response rate (Soetento, 2006). The questions were both closed and open-ended, and formatted using a 5 – point likert scale for each attribute of question. The questionnaire samples can be found in Appendix 3A, 3B and 5A.

For the first two case studies, the questionnaires were divided into four different sections.

The first section focused on the overview of the implementation, with four different questions being asked on; the effectiveness of the LPS implementation; the fulfilment of results obtained; the usefulness of the Weekly Work Plans (WWP) and the Percentages of Plans Completed (PPC); the degree of difficulty experienced while implementing the LPS.

The second section on the other hand, centred on the barriers faced during the implementation process. Six possible barriers derived from the literature search and the other research processes were identified. The respondents were asked to determine the frequency of occurrences of these barriers.

Similarly, the third section dwelt on the critical success factors of LPS. Different factors were identified from literature reviews and respondents were asked to determine their frequency of occurrence.

Conversely, the fourth section focused on the perceived benefits of implementing LPS. The researcher also identified from literature reviews 10 possible benefits of implementing LPS within the two case studies and respondents were asked to determine their frequency of occurrence.

Furthermore, for the other third case study project, the questions in the questionnaires were divided into three sections with the first section requesting general information on the project participants. While the second section focused on the current construction culture of the study project, this was in terms of attitudes, behaviours and actions recorded on site. The last section dwelt on the current construction practice in place and the overall performance of the project.

4.5. SUMMARY OF THE DATA COLLECTION METHODS

The summary of the entire data collection methods is illustrated in Figure 4.2. The figure also showed that the different sources of data have provided a triangulation of sources, thereby strengthening the data collection methodology.

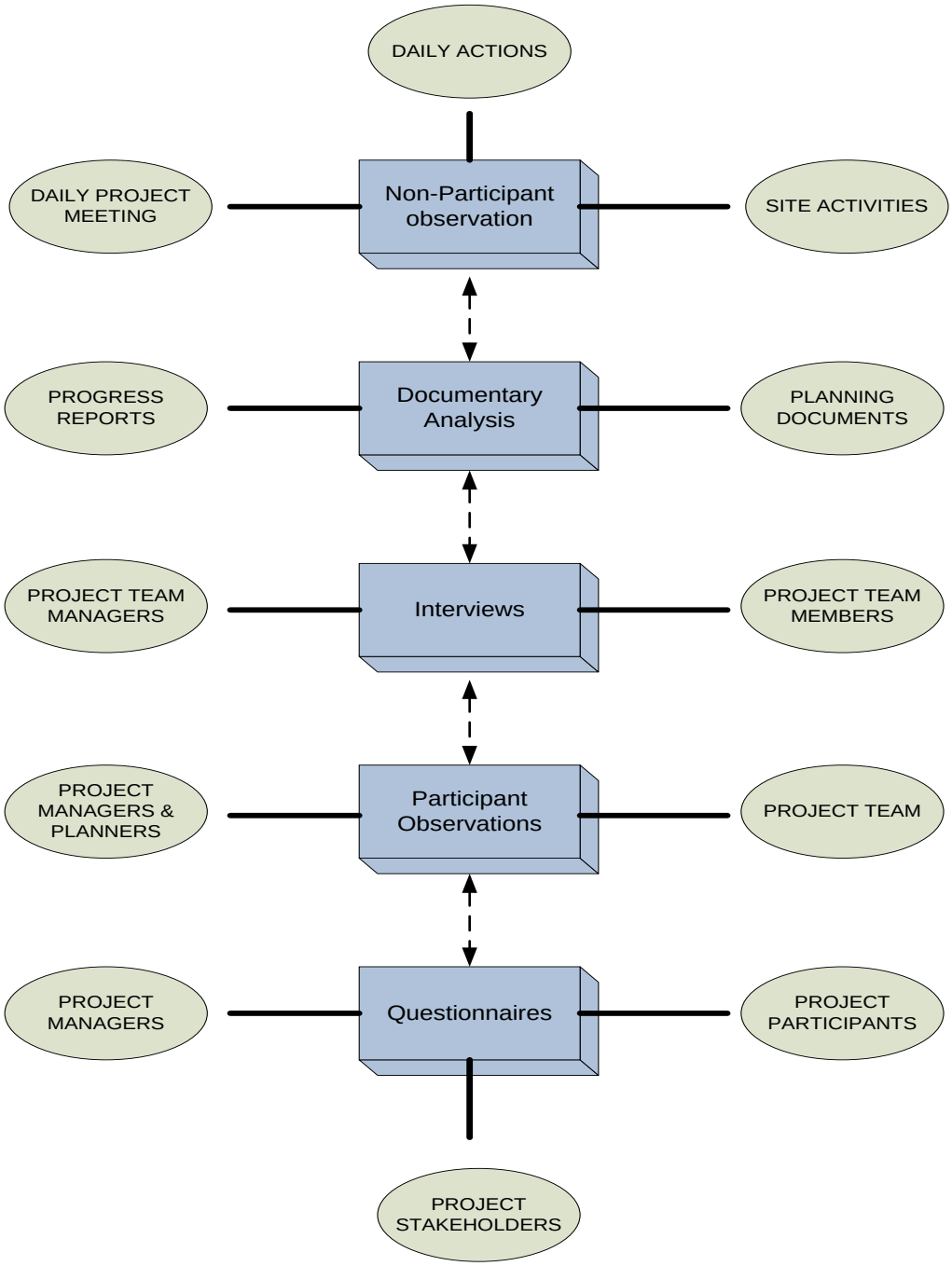


Figure 4.2 Summary of Data Collection Methods

4.6. DATA ANALYSIS

Data analysis is the process of bringing meaning and interpretation to mass data collected (de Vos *et al.*, 2002). Amaratuga *et al*., (2002) identified that data analysis, forms a major part of any research. It consists of examining, categorising and tabulating data obtained (Yin, 2003; Miles and Huberman, 1994).

In this research, a structured literature review was first conducted and it served as the foundation for the research. The empirical data gathered was both qualitative and quantitative in nature and they were used to establish the link between the literature reviews. Questions were asked using questionnaires and interviews.

For the questionnaires, a Likert scale was used to access the views of the participants. Dendcombe (2007) indicated that Likert scales fall within the ordinal level of measurement which means that the responses are categorised and ranked into the following categories; never, rare, seldom, frequent and very frequent. The categorisation and ranking enables priorities to be allocated (Bryman, 2008; Laerhoven *et al.*, 2004).

In carrying out this research, the Ranking Indices of Importance (RII) was used. RII is commonly used to measure the extent to which the occurrence of an outcome exists (Sergent and Firth, 2006). The following formula was used to calculate RII

$$RII = \frac{\breve{x}}{k}$$

Where $\breve{x}$ = mean = $\frac{\sum fx}{\sum f}$

k = maximum point on likert scale (e.g k = 5)

x = points on the Likert scale (1, 2, 3, 4.....)

f = frequency of respondents choice

For the interpretation of the RII values, RII is ranked from the highest to the lowest.

If $RII < 0.60$ item has low rating

$0.60 < RII < 0.8$ item has high rating

$RII \geq 0.8$ item has very high rating

Other statistical analysis were also employed using simple Microsoft excel and word to present a visual representation of the patterns and trends of the data, especially for the PPC presentations and the reasons for incomplete assignment calculations.

4.7. DATA EVALUATION

Design science is seen as a basis of problem solving research (Holmstrom and Ketokivi, 2009). In view of this Jarvinen (2007) contends that Action Research and Design Science Research are similar research approach. However, for any researcher undertaking an Action Research or any form of constructive research, the researcher has an additional responsibility to measure the data for reliability, validity and representativeness (McNeil, 1989). To this end, this research seeks to review these same concepts (reliability, validity and representativeness) in addition to other concepts such as flexibility, rigour and reflexivity in relation to the data obtained.

4.7.1. RELIABILITY

Reliability as an evaluation criterion, measures results obtained to determine if they produce a consistent result over a repeated test from other similar tests (King *et al.,* 1994). A typical DSR tests the technological rules used within the research process (Van Aken, 2004).

In carrying out this research, the technological rule being tested is the Last Planner System as implemented in the Nigerian construction environment. The research tests technological rules by extracting and developing multiple case studies. It uncovers technological rules already in use and applies it in collaboration with people within its field in a new environment.

On the contrary, Ballard (2000) identified that reliability could be questionable with the active role usually played by researcher while carrying out a DSR. This is obvious because, reliability concerns the extent to which research can be repeated by others and the same results obtained.

Van Aken (2004) argues that in DSR, the researcher has to play an active role while creating innovations by testing the technological rule applied. Similarly, March and Smith (1995) identified that while evaluating an outcome in DSR, it should depend on the effectiveness of the artefact and the impact it has on its environment and users.

In conducting this research, the researcher ensured that the interview respondents were not biased with the active role of the researcher during the implementation. Hence the questions were short and simple giving the respondents (contactors, clients, consultants, sub-contractors and suppliers) the opportunity to express themselves by given the actual situation within the project.

4.7.2. VALIDITY

This refers to the degree to which inference can legitimately be made from the study. It probes to find out if the data collected is a true picture of what is being studied (McNeil, 1989, King *et al.,* 1994).

In carrying out this research, data triangulation was utilised as a strategy to increase the validity of the research. This involved sourcing for data in multiple case studies using multiple sources of evidence. Consequently, this helped in providing an appropriate account of the finding of the research.

4.7.3. REPRESENTATIVENESS

Representativeness of data simply implies that the data reflects the make-up group (Bazerman, 1994). It ensures that the object of study is typical to the larger population so that when the

results are extrapolated generalisations could be made (Bass and Firestone, 1980). Although this could be a dilemma in constructive and Design Science Research, as it usually has a limited number of study projects (Robson, 2002).

However, Ballard (2000) demonstrated that a single project could establish representativeness. This, the author argued could be possible if the intervention is successfully carried out, to show that similar actions can produce similar outcomes in a different situation. In carrying out this research, it was proven that carrying out the same actions within Nigerian context could produce similar outcomes.

This was proven from the two case studies in which LPS was implemented on different construction projects at different locations. Furthermore, other than using a single study, the researcher used three case studies to ensure representativeness of the data (the first two cases described LPS implementation while the third was a study on a successful project in Nigeria, in comparison to LPS projects). Hence, the results of the findings can be generalised and used as a point of reference for the implementation of Lean Construction in similar projects in Nigeria.

4.7.4. FLEXIBILITY

Flexibility is concerned with the possible change in the direction of the research (Lincoln and Guba, 1985). DSR is flexible as it typically involves the following processes as sighted in Kasanen *et al.*, (1993)

1. Find a practical relevant problem which has a research potential
2. Obtain a general and comprehensive understanding of the topic
3. Innovate by constructing a solution idea.
4. Demonstrate that the solution works
5. Show the theoretical connections and the research contribution

6. Examine the scope of applicability of the solution

These processes highlighted above shows that the research design can always be refined, as the researcher learns more about the real life situation.

4.7.5. RIGOUR

Rigour is identified in Robson (1993) as the main dilemma facing this kind of research (Constructivist and Design Science Research) because it has little or no structure to validate it. However, Dick (1999 and 2000) argues that the Constructivist Research Approach and the Design Science Research draws upon many sources of rigour similar to what is obtained in a qualitative research approach.

Dick (1999) compared these sources to the use of multiple sources of data collection and evaluation together. The fact that DSR involves designing and constructing (building and evaluating) an artefact, while checking that the original problem has been solved demonstrates rigour (Hervener *et al.*, 2004). Rigour is evident in this research since the research methods represent the exact, detailed and expressive pictures of the research situation.

4.7.6. REFLEXIVITY

Reflexivity refers to the level of bias a person's thought could represented in their work (Jupp, 2006). It is also seen as a deviation from a rational pursuit of inquiry (ibid). In carrying out a DSR and an Action Research, Paassen *et al.*, (2011) observed that the researcher plays an active role in: the selection of information; and the researcher also influences to a greater degree the people involved in the work.

Hence, Somekh (2006) stated that the quality of any research depends on the reflexivity of the researcher. The researcher being aware of this tried to be unbiased during the data analysis and the interpretation of the results obtained.

4.8. DATA SAMPLING

Sampling is the process by which inference is made to the whole by examining a part and sampling occurs generally when the population is too large to study in its entirety. Hence the sample selected would be representative of the general population (Tashakkori and Teddlie, 2010). Within this research, the target population is the Nigerian construction industry. Case projects are selected to produce these kinds of insights as representatives of the general population. Generally, there are two basic types of sampling (Salganik and Heckathorn, 2004):

1. The probability sampling
2. Non-probability sampling

1. The probability sampling: This is type of sampling in which the entire unit in the population has a chance of being selected in the sample, and it is possible to specify the probability of selecting any particular sample of a given size within the population (Salganik and Heckathorn, 2004)

2. Non-probability sampling: In this sampling method, the probability of selection cannot be determined and some elements of population do not have any chance of selection. It basically involves selecting elements of the population based on assumptions regarding the population of interest, which forms the criteria for selection (Salganik and Heckathorn, 2004).

4.8.1. SAMPLING OF THE CASE STUDY PROJECTS

Sampling of the case studies involved a non-probabilistic sampling. Here the sample is being drawn from selected elements of the population which is readily available and convenient. The process of implementing LPS within the case studies entailed an AR within ongoing construction projects, at its inception stages. Figure 4.3 illustrates the different geographic locations for the three case studies

Figure 4.3 Geographic locations of the three case studies

The case studies reported within this research were selected based on the availability of this variety of projects and at different locations of the country. Case study one was a building project, while case study two was a road construction project. In addition, the third case study was a multipurpose hydropower dam infrastructure project.

4.8.2. SAMPLING OF PARTICIPANTS

1. THE INTERVIEW PARTICIPANTS: Throughout the research process within each case study, only senior management personnel (project managers, project consultants, project engineers and site engineers) were selected for interviews. This was because they could provide detailed information on how the projects were planned, controlled and managed.
2. QUESTIONNAIRE PARTICIPANTS: Questionnaire surveys were sent to all the project participants that were involved in LPS implementation. This includes: contractors, subcontractors, suppliers and consultants.

3. FOCUS GROUP: The sample size for any focus group is usually between 8 to 12 participants (Duggleby, 2005). Similarly, within this research, 12 senior construction professionals experienced in different construction projects and residing within the same geological location (Abuja, Nigeria) were contacted for the focus group. However only 8 persons showed up and participated in the focus group process.

4.9. FRAMEWORK DEVELOPMENT

A frame work was developed from the outcomes of the literature reviews and case studies. The literature reviews revealed possible barriers to change initiatives in Nigeria, this was used to match LPS implementation barriers from other case studies. Consequently, the barriers (cultural issues, lengthy approvals, resistance to change, subcontractor's involvement, poor supervision and quality control, fluctuation and variation) were classified using the criteria of linear causality. These barriers were measured while carrying out the LPS implementation in Nigeria.

Subsequently, a framework was developed to mitigate these barriers. Full details of how the framework was developed are found in section 8.3 in this thesis.

The basic idea of DSR is to 'build' and 'evaluate' (March and Smith, 1995). Build here refers to building a solution to an existing problem, while evaluation entails assessing the usefulness of the solution. Within this research, a framework is built and evaluated using focus group discussions demonstrating a typical DSR cycle, of 'build' and 'evaluate'.

4.10. FRAMEWORK EVALUATION

The framework was tested and evaluated using a focus group evaluation process. Wilkinson (2004) described a focus group as a way of collecting data by engaging a small group of people in an informal discussion on a particular topic. Similarly, Robinson, (1999) defined a focus

group as an in-depth, open-ended group discussion between 5 to 8 participants that lasts within one or two hours, while exploring specific issues.

A focus group usually has the following purposes as sighted in Kruegar and Casey, (2000):

- To determine program effectiveness and improvement.
- Organisational development
- Customer satisfaction
- Policy making, testing and evaluation
- Identifying strengths and weaknesses of a framework

Distinctively, a focus group is conducted using an interview to obtain the data. Robinson, (1999) described that it entails interviewing a group of people at the same time. The participants are asked a series of questions by the facilitator and the other participants hear the responses of the participant. However, they are allowed to either agree or disagree or also make additional comments to response to the answer from the participant.

Morgan (1988) indicated that the interaction that occurs within focus groups enables complex dimensions to be revealed and it usually yields important information. Furthermore, Robinson (1999) identified that it probes assumptions that give rise to particular views and opinions about specific issues. The main advantage is that it allows information to be expressed in the participants own words and context without having constrained categories (ibid).

The focus group process was used as a measure to test and evaluation the framework. The full details of the focus group testing and validation process is described in section 8.4 to 8.6. Similarly, the findings from the focus group session are discussed in section 8.7 of this thesis.

4.11. ETHICAL CONSIDERATIONS

In conducting an Action Research, human participants are treated as collaborators rather than as subjects, hence ethical considerations for such researches is very minimal (Bailey, 2007). However in carrying out this action research, ethical issues were considered to be of high priority. Hence, it was considered throughout the research process, from the case designs, to the selection of data collection methods, and throughout the implementation processes.

The whole research was conducted in a way that ensured that confidentiality and integrity of the participants were respected. The researcher gave forethought to the maximisation of the research benefits and the reduction of research risks that might occur from the research. Hence particular concerns were given to the participants of the case studies. They were informed of the research aim and objectives and the consent was sort to participate on voluntary basis.

Critical reflections on ethical aspects of the case studies were done prior to conducting any field study. Similarly, an ethical approval form was submitted to the ethics committee at the University of Wolverhampton, and approvals were obtained in June 2011. Furthermore, participants were guaranteed that all information would be handled with strict confidence and anonymity of each participant (Saunders *et al.*, 2007).

4.12. CHAPTER SUMMARY

This chapter has presented the methodology and research design utilised in carrying out this research. Similarly, the research strategy, data collection, analysis and evaluation techniques adopted were also presented. Design Science was used as the research approach, while Action Research was used for the research strategy.

Data was collected using observation and documentary analysis, interviews and questionnaire surveys. The quantitative data obtained were analysed using the Ranking Indices of Importance

(RII), while Microsoft excel and word were used to present the data. Furthermore, data was evaluated using the following tests: reliability, validity, representativeness, flexibility, rigour and reflexivity. Finally, the ethical concerns with regards to the data collection process were also emphasised.

5. Chapter Five - CASE STUDY 1(HOSTEL BUILDING)

5.1. INTRODUCTION

This chapter presents a hands-on application of the Last Planner System, which was suggested in chapter three as a possible improvement to the way construction is managed and controlled in Nigeria. It has been further introduced and explained in chapter four. Hence, this chapter presents the research results of implementing the Last Planner System in the construction of a prototype hostel project building in Nigeria. It reports the implementation process as a reference case study of an improved management practice that can be adopted in construction processes in Nigeria.

The case explores the arguments put forward in the research question:

> *Can Lean Construction tool; the Last Planner System, be successfully applied to improve construction processes within Nigeria?*

The answer to this question is reported within the case studies presented in this thesis.

The chapter begins with a background of the case study and also describes the details of the study project. It then delves into how data was gathered during this study. It further describes the researcher's full involvement by presenting a detailed account of the outcomes from the observations, interviews and survey questionnaires. The chapter ends by discussing the implementation challenges and the success factors of the implementation as well.

5.2. CASE BACKGROUND

The case study was carried out in a University located in the North central region of Nigeria. It entailed the construction of four prototype student hostel buildings by four different contractors. Each contractor had the same design and scope for the building. The four projects were to be

located at the Universities permanent site, which was located 90 Kilo-meters from the University campus.

The contract value for each of the projects was approximately N300,000,000.00 (approximately, £1,200,000) with an estimated project duration of 18 months. The project location had no access road and was in a virgin land in a thick forest. It was approximately 150 Kilo-meters from the nearest small town and 350 Kilo-meter from the nearest city. Hence, it was a peculiar project with inherent challenges of access, communication, safety and distance to and from regular suppliers. Consequently, these challenges hampered the progress of the project and the four contractors admitted that this project was the most challenging project they have ever embarked on. The details of the four contractors are further discussed below.

CONTRACTOR 1 (CRT1)

Contractor one with code name CRT1 was an indigenous contractor with an average of 80 employees and that included project managers, engineers, quantity surveyors, land surveyors, architects, planners, builders, foremen, carpenters, plumbers and bricklayers. The contractor specialised in the construction of buildings and real estate. The company was founded in 2004 and its CEO is also a professional engineer who has been into construction activities since 1979.

The company has successfully completed several commercial and residential buildings in different cities in Nigeria. However, this was the first time they were handling a project in the north central region of Nigeria.

CONTRACTOR 2 (CRT2)

Contractor two with code name CRT2 was an indigenous contractor and was founded in 1994, popularly known to be a multi service construction company engaged in the construction of different infrastructural projects, ranging from industrial buildings to agricultural warehouses,

offshore structures together with other public infrastructure projects. However, most of these projects were carried out in major cities in Nigeria and the contractor was carrying out a project for the first time at the north central region of Nigeria. The contractor also had an average of 120 employees with its top level organisational structure similar to figure 5.1. The figure is used to depict the top management of CRT2.

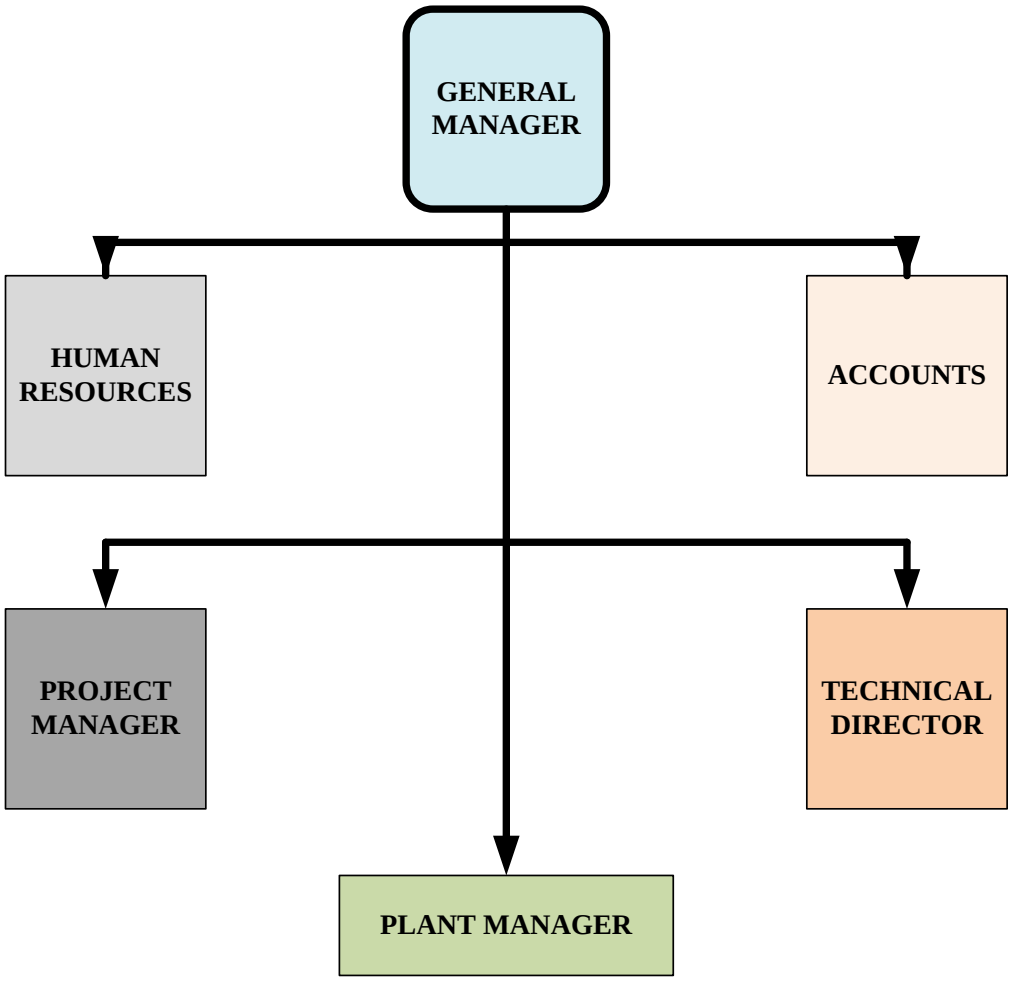


Figure 5.1 Top Level Organisational Structure of CRT2

Additionally, it was observed that the project manager assigns work to the project engineers who in turn direct site engineers on how to carry out the work. In carrying out this project, the contractor deployed over 40 of its employees to the site.

CONTRACTOR 3 (CRT3)

Contractor three with code name CRT3 was known to be a leading indigenous construction company established since 1989. The company is involved in different engineering projects including buildings, mechanical, industrial and electrical infrastructure projects. The head office of the company is located in Abuja the Federal capital territory of Nigeria, and it has 4 other branch offices located in 4 major cities in the country.

The company was made up of experienced indigenous engineers, architects, planners and surveyors, with staff strength of about 200 employees.

CONTRACTOR 4 (CRT4)

Contractor four with code name CRT4, a fully indigenous building construction company established and incorporated in 1999. It has since then been involved in the construction of buildings, real estates and other housing development projects. They have successfully constructed and completed housing estate development for corporate and private clients. CRT4 has a pool of skilled personnel made up of experienced engineers, builders and surveyors. They had an average 85 permanent staff.

5.3. SUMMARY OF CONTRACTORS PROFILE

A summary of the four contractors engaged to carry the construction of the four prototype project is shown in Table 5.1

Table 5.1 Characteristics of the four contractors

Code name for each contractor	CRT1	CRT2	CRT3	CRT4
Average no. of employees	80	120	200	85
Area of specialisation	Buildings	Infrastructure	Engineering	Buildings
Years of experience	10	20	25	15

5.4. CASE DESCRIPTION

The researcher reached out to the four contractors asking if the Last Planner System (LPS) could be implemented to their construction project. However all the contractors were not willing to be a part of the research, only one of them (CRT4) agreed to implement the LPS. The researcher was hoping at least two of the contractors would have accepted to implement LPS so as to compare results.

This research within this prototype project was performed in an action research environment, where the researcher served as the facilitator during the LPS implementation. The researcher worked with project engineers at the site with a lot of assistance from the project manager as well.

The data gathered were in phases comprised of pre-implementation, implementation and post-implementation phases. For the pre-implementation phase, the data was collected using non-participant observations and interviews. While for the implementation phase, data was collected using participant observations and documentary analysis. Finally, for the third phase, data was collected using survey questionnaires and this was the post-implementation phase.

Details of these phases are shown in Table 5.2

Table 5.2 Phases of data collection process

Phase 1	Pre-Implementation	- Non-participant observations - Interviews
Phase 2	Implementation	- Participant observations - Documentary analysis
Phase 3	Post-Implementation	- Questionnaires

These phases formed multiple sources of data collection which also provided triangulation of sources of data for the research, hence increasing the confidence of the findings (Bryman, 2006).

5.5. PHASE I – PRE-IMPLEMENTATION

5.5.1. NON-PARTICIPANT OBSERVATION

The researcher having gained approval from the client and contractor (the University authorities where the project was taking place was the client), went to the entire construction site where the four projects were going on and undertook a thorough site observation, recording and observing how site activities were planned and controlled, without necessarily interacting with the project participants. The following were the items the researcher looked out for within the non-participant observation:

- Current Planning practice in terms of labour and material schedules
- Frequency of site meetings
- Site coordination
- Communication and relationships

These items served as the check list for the non-participant observations and it gave the researcher an insight on the current planning practice within each project site. Furthermore, the researcher observed and recorded how work was planned, structured and controlled by team leaders at the site. This also gave the researcher an idea of the contractor's management systems in place. Additionally, the researcher gained insight on communication systems in place together with the relationships that existed between each project participant.

5.5.2. INTERVIEWS

The interview sessions were undertaken to ascertain the available planning, control and management practice among the four contractors hence the project managers/ site managers,

project engineers and planners for the four companies were interviewed. The interviews gave a detailed account of how each contactor planned and executed their project. A semi-structured interview using open ended questions was used to establish the common planning technique of the individual contractor (see Appendix 2A for the interview questions).

5.6. SUMMARY OF PHASE I

The data collected from the four contractors during the observations and interview sessions are discussed in this section. The researcher started with the non-participant observation, this was followed by the interviews, which served as a validation of the finding obtained from the observation process. These findings from the individual contractors are discussed below.

5.6.1. CONTRACTOR I – CRTI

From the non-participant observation, it was identified that labour was not properly coordinated within the site and construction materials were found to be located in different areas of the site with very poor housekeeping. The non-participant observation started on the 23th of July 2012.

The researcher noticed there was no site meeting in place and this was confirmed during the interviews where the respondents stated that there was no formal arrangement to hold regular meetings rather meetings occurred as the need arose. Furthermore, it was recognised that work was planned by the project manager who was not resident at the site and the planned work was given to the site engineer to execute. Hence the site engineer was saddled with the responsibility of managing the work planned from the head office. Another challenge experienced at the site was the lack of communication tools and a conflicting relationship between the project manager and the site engineer and this affected how work was carried out and this created tension among the other project participants.

Similarly, the interviews revealed that there was no communication tool (i.e. walkie talkie) provided for the site, and that the contractor did not practice any special project management system. They also indicated that they were not aware of Lean Construction or the Last Planner System.

5.6.2. CONTRACTOR 2 – CRT 2

From the non-participant observations, it was observed that labour was coordinated by the foremen at the site, and no attention was paid to material flow and access (site movement). The researcher also observed that weekly site meetings were planned but could hardly take place because of the stage of work they were handling. This was also confirmed during the interviews by the respondents who stated that meetings were scheduled to take place on a weekly basis but were not actually regularly taking place.

The project was managed using a push system, where instructions were pushed to the foremen on how to coordinate the site and the interview respondents stated that they were not using any special project management system. They however also indicated that they were not aware of Lean Construction or the Last Planner System. Nevertheless, there was a good and cordial relationship among the project participants although no special communication gadget (i.e. walkie talkie) was used for communication.

5.6.3. CONTRACTOR 3 –CRT3

From the non-participant observations it was observed that labour and materials were properly coordinated and scheduled around the site. A site manager was responsible for the coordination of activities within the site, with other professionals assisting him on each section of the project. However, it was observed that the numbers of professionals coordinating some sections were necessarily not adding value to the project and could serve as an extra overhead cost on the site.

From the interviews it was indicated that site meeting were held regularly on a daily basis and the project management technique practiced by the contractor was the Critical Path Methods (CPM). Some of the interview respondents stated that they were conversant with Lean Construction but have however not adopted its principles in any project.

Furthermore, the researcher observed that there was a good relationship among the project participants at the site and that modern communication tools (i.e. walkie talkies) were in place.

5.6.4. CONTRACTOR 4 –CRT4

The researcher observed a poor coordination of materials and labour by the site manager. Site activities were not properly planned or structured making the site look awkward. It was observed that site meetings were frequent but not regular (i.e. it was not daily, weekly nor monthly). From the interviews, it was revealed that the there was no special project management approach in place and the interview respondents were not aware of Lean Construction. Furthermore, there was no communication gadget in place, although there was a coordinal relationship between the project participants.

Tables 5.3 summaries and compares the non-participant observation that took place in the for project sites, while tables 5.4 summaries and compare the findings from the interviews.

Table 5.3 Findings from the non-participant observation with the four contractors

Themes	Contractor 1 – CRT1	Contractor 2 – CRT2	Contractor 3 – CRT3	Contractor 4 – CRT4
Current Planning practice in terms of labour and material schedules	Poor labour coordination	Labour was coordinated by foremen and less attention was given to flow of materials	Labour and materials were properly coordinated	Poor coordination of materials and labour by the site manager
Frequency of site meetings	No weekly or daily site meetings	Weekly site meetings but not regular	Daily and regular site meetings	Frequent but irregular site meetings
Site coordination	Project manager made plans in the head office, while the site engineer implemented on site	Push method of management. Where work is pushed from top management level	Work is properly structured but not properly coordinated	Poor control of site and poorly structured management of daily site activities
Communication and relationships	Poor communication channels and adversarial relationships	Good communication channel but no special communication gadget. Cordial relationships	Good communication channel with modern communication gadgets	Verbal communication and no communication gadget. Cordial relationships

Table 5.4 Findings from the interviews of the four contractors

Themes	Contractor 1 – CRT1	Contractor 2 – CRT2	Contractor 3 – CRT3	Contractor 4 – CRT4
Current Planning - Frequency of site meetings	Meetings are held as the need arise	Meetings are held weekly	Meetings are held daily	Meetings are held frequently
Control – Site manager	The project manager and site engineer are in charge	Foremen are in charge of site coordination	Site engineers coordinate different sections of the site	Project manager and site manager coordinates the activities at the site
Communication gadgets	No communication gadget	No communication gadget	Communication gadgets like walkie talkies are were used	No communication gadget
Project management systems in place	No special project management system	No special project management system	Critical Path Methods (CPM)	No special project management system
Lean Awareness	Not heard of lean construction	Not heard of lean construction	Aware of Lean Construction but have never practiced it.	Not heard of lean construction

5.7. PHASE 2 – IMPLEMENTATION PROCESS

The researcher introduced the concepts of Lean Construction and the Last Planner System to all the four contractors carrying out the construction of the hostel prototype project. However, only the fourth contractor CRT4 was enthusiastic on improving the way they previously coordinated, planned and controlled site activities.

The implementation commenced with an introductory workshop on the concepts of Lean construction and the Last Planner System. The workshop was held on the 27th and 28th of July 2012, and the management of CRT4 ensured that all the project participants including its subcontractors were a part of this workshop program.

The main aim of the workshop was to introduce the concepts of Lean construction and explain how the Last Planner System works. The first day of the workshop was used to illustrate the benefits of Lean construction as applied in other countries and introduce the features of the Last Planner System. While the second day of the workshop was more practical with the researcher demonstrating practically how LPS works in construction projects. The project participants were grouped into smaller teams and they were each given a demo project consisting of 3 tasks to practice the implementation of the LPS process.

At the end of the workshop sessions most of the project participants had an idea on how to fill out the LPS forms for phase scheduling, look ahead plans, weekly work plans and how to calculate the Percentage of plans completed. Conversely, the actual implementation started on the 30th of July 2012, although the contractor had progressed with most of the work on site. The researcher was still able to incorporate the LPS to the project. This was possible because of the feature of the Last Planner System. These features include: the master plan; phase planning; look-ahead planning; weekly work plans and the Percentage of Plans Completed (PPC).

For the Master plan, the researcher re-examined the project deliverables by outlining the general idea of the project objectives. The milestones were located and different time frames were set to complete the planned work. Furthermore, these milestones were divided into phases which were referred to as phase schedules.

For the phase scheduling, different teams were involved in constructing different aspects of the project. They established the context of the work, defined the milestones deliverables, developed an execution strategy and identified how each task should be carried out.

It was a face to face interaction among the project participants with each team agreeing to execute their corresponding tasks in an agreed time frame. These activities in the phase plans were classified as look-ahead schedule and it was basically extracted from the master schedule. These comprised of planned activities that should last for a period of four weeks with an individual responsible for carrying out the activities.

Subsequently, the look-ahead plans were jointly created with each team. These teams identified possible constraints to the planned tasks. This was achieved using constraint analysis charts. They were handed to each team to anticipate future needs like resources or labour, or other constraints that could possibly hinder the planned work. Consequently, each team ensures that the identified constraints were removed before the activities in the activities in the look-ahead charts are planned as weekly work plans.

The weekly work plans served as a weekly update of the look-ahead plans and the activities in the weekly work plans were activities that were ready to be performed (Activities whose constraints have been removed). Furthermore, at the end of every week, the Percentage of Plans Completed (PPC) were all calculated and documented together with the reasons of incomplete assignment charts. The look-ahead charts, constraint analysis charts, weekly work plan charts,

percentage of completion chats and reasons for incomplete assignment charts are all found in Appendix 6 (6A-6E).

The implementation lasted for up to four months and the researcher documented the weekly work plans and analysed the weekly PPC calculated. Conversely, the PPC's were grouped into 4 weeks and their averages analysed.

5.8. SUMMARY OF PHASE 2

At the end of the project, the fourth contractor CRT4 in comparison with the other contractors had a better allocation of resources, an organised workflow and an enhanced control of the project. Even though the LPS implementation started off after the project had already commenced with different trades already working, the contractor had a superior management of the project. Though, it was not an easy task for the contractor's employees who were already working with a familiar system on this project to embrace a completely new system. This served as a major obstacle to the implementation.

However, at the end everyone that participated enjoyed being a part of the decision making process. It promoted collaborative learning from the reasons of incomplete assignments. Additionally, CRT4 received information on project success and failures regularly from the weekly PPC's and the constraint analysis were used to check possible hitches before they became problems to the project. For example, all the contractors suffered from similar challenges, a prominent one being shortage of materials which was as a result to scarcity of reinforcement materials. CRT4 was able to overcome this challenge by regular short term look-ahead planning. The contractor envisaged the problem and dwelt with it on time before it became a real issue.

From table 5.5 and figure 5.2 the average PPC is 41.67% which is a very low PPC. The reasons for the incomplete assignments that led to a low PPC is shown in figure 5.3

Table 5.5 Comparison of 4 weeks of PPC (30/7/12 – 26/8/12)

Weeks	No. of completed tasks	No. incomplete tasks	Total tasks	PPC
30/7/12 – 5/8/12	7	5	12	58 %
06/8/12 – 12/8/12	4	9	13	31%
13/08/12 – 19/08/12	4	8	12	33%
20/08/12 – 26/8/12	5	6	11	45%
	20	**28**	**48**	**42%**

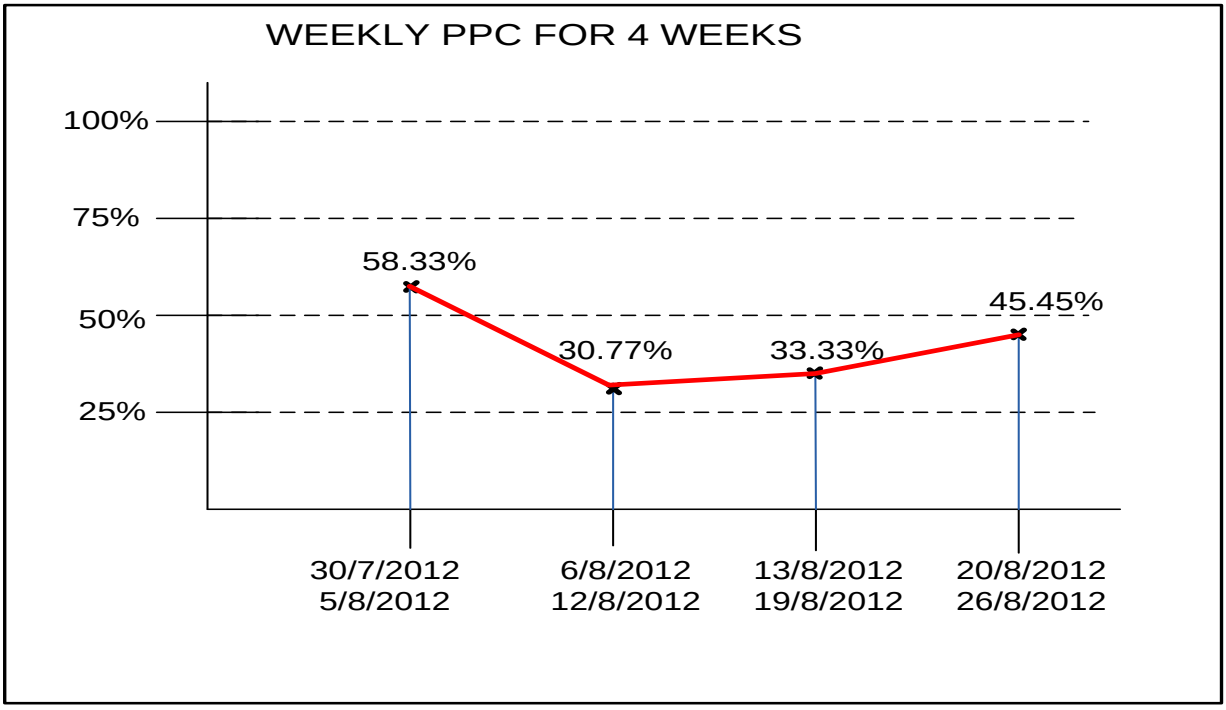


Figure 5.2 Weekly PPC for four weeks (30/7/12 – 26/8/12)

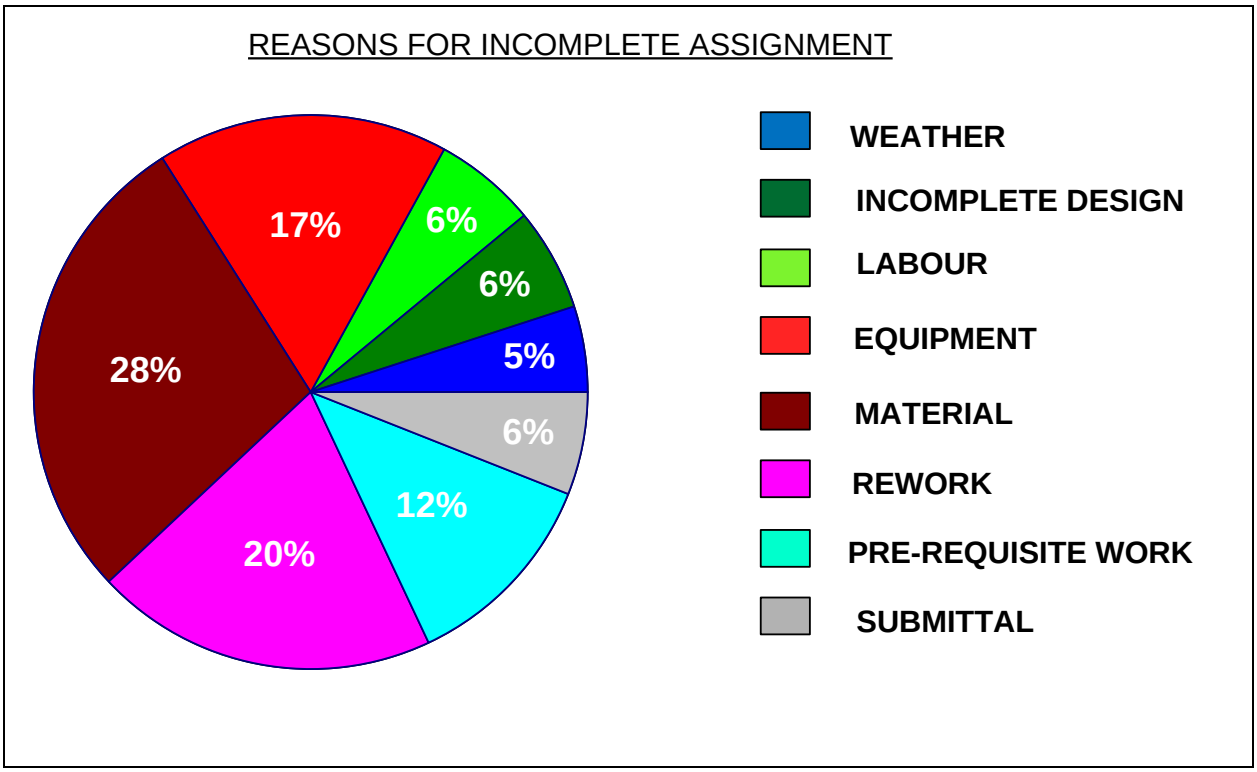


Figure 5.3 Reasons for incomplete assignment for (30/7/12 – 26/8/12)

It is observed that material unavailability had the highest percentage of 28% compared to the other eight reasons for incomplete assignments. Other major reasons include rework (20%), equipment breakdown/unavailability (17%) and pre-requisite work (12%). On the contrary, the least common reasons for incomplete assignments include submittals i.e. late request (6%), labour (6%), incomplete designs (6%) and poor weather (5%).

The problem of material shortage was a huge challenge for the project. Suppliers found it difficult to convey materials to the site because of the site terrain. Another reason for the shortage of materials was the scarcity of reinforcement materials in the whole country.

Table 5.6 Comparison of four weeks PPC (27/8/12 – 23/9/12)

Weeks	No. of completed tasks	No. incomplete tasks	Total tasks	PPC
27/8/12 – 02/9/12	7	5	12	58%
03/9/12 – 09/9/12	6	6	12	50%
10/9/12 – 16/9/12	7	6	13	54%
17/9/12 – 23/9/12	7	5	12	58%
	27	**22**	**49**	**55%**

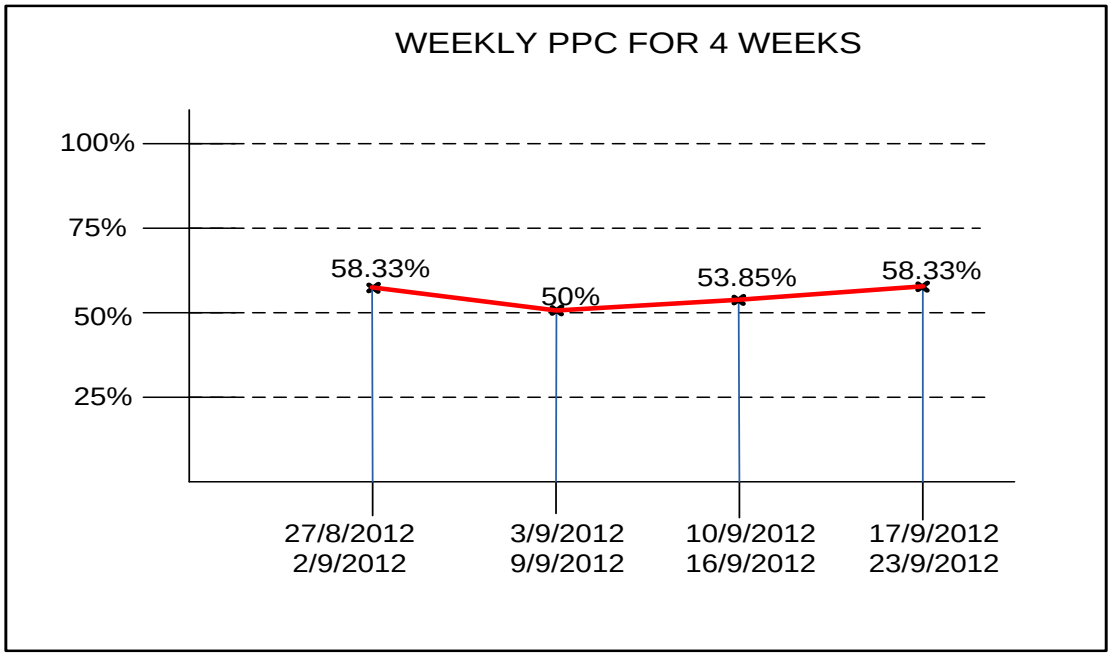


Figure 5.4 Weekly PPC for four weeks (27/8/12 – 23/9/12)

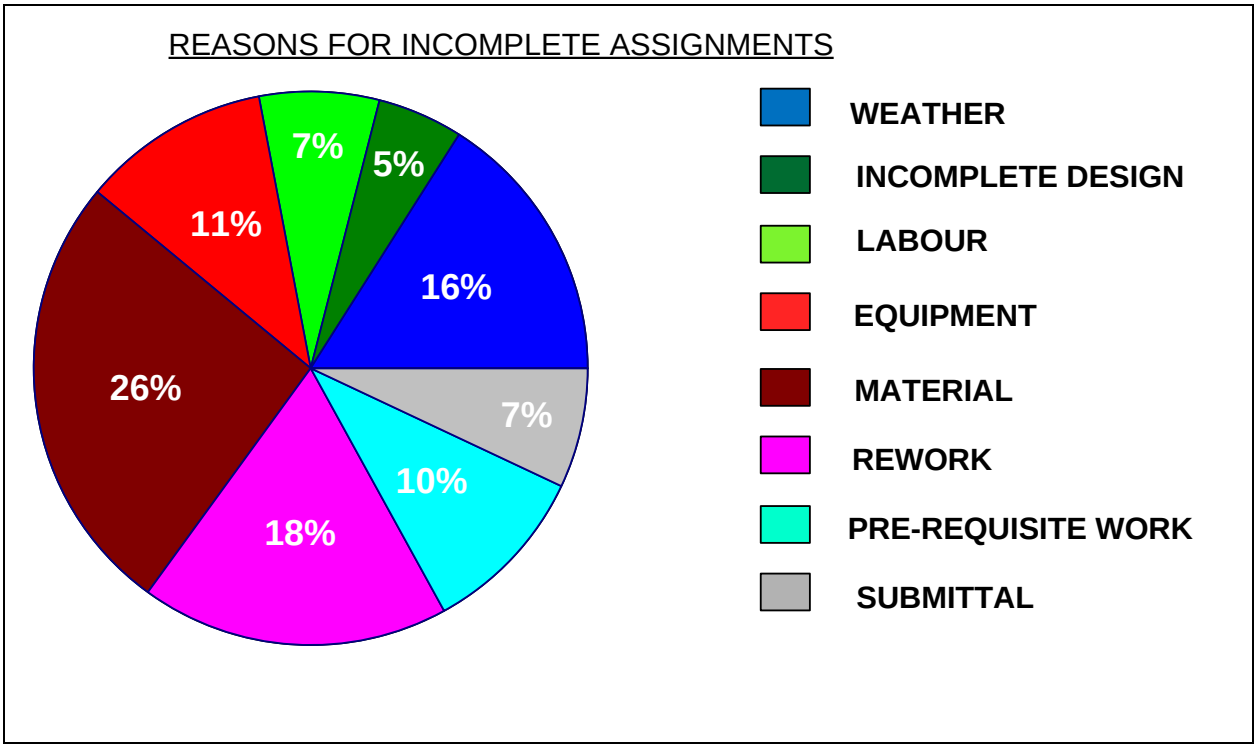


Figure 5.5 Reasons for incomplete assignment for second look-ahead schedule (27/8/12 – 23/9/12)

Furthermore, table 5.6 indicates the PPC's recorded within the second look-ahead schedule (second month) of the implementation. The average PPC recorded was 55%. This was higher than the average PPC (42%) recorded in the first look-ahead schedule. It was also identified that the major reasons for incomplete assignments were; material unavailability (26%), rework (18%) and poor weather (16%). Other reasons were equipment breakdown (11%) pre-requisites (10%) labour and submittals (7% each) and incomplete design (5%).

There was an improvement in the average PPC's as each team saw the importance of keeping reliable promises. The PPC's for the third look-ahead schedule shown table 5.7 and figure 5.6 shows a remarkable improvement on the PPC's and the average PPC recorded within this four weeks is 75%.

Table 5.7 Comparison of four weeks PPC (24/9/12 – 21/10/12)

Weeks	No. of completed tasks	No. incomplete tasks	Total tasks	PPC
24/9/12 – 30/9/12	11	2	13	58%
1/10/12 – 7/10/12	8	3	11	50%
8/10/12 – 14/10/12	9	3	12	54%
15/10/12 –21/10/12	8	4	12	58%
	36	**15**	**48**	**75%**

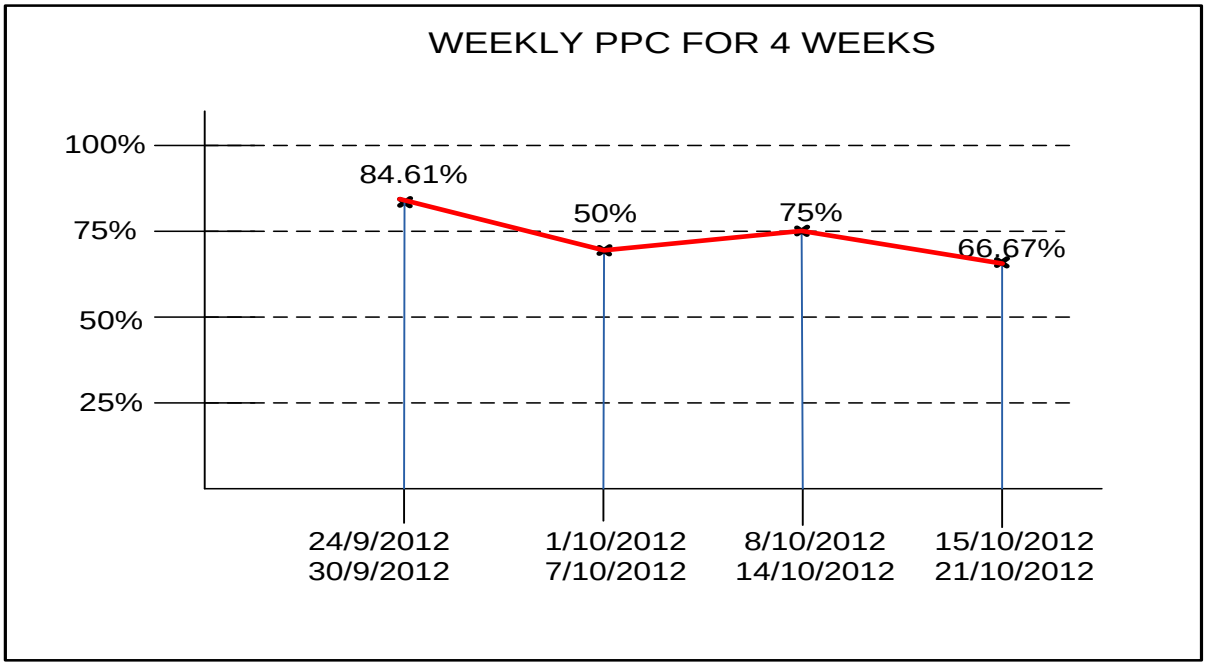


Figure 5.6 Weekly PPC for four weeks (24/9/12 – 21/10/12)

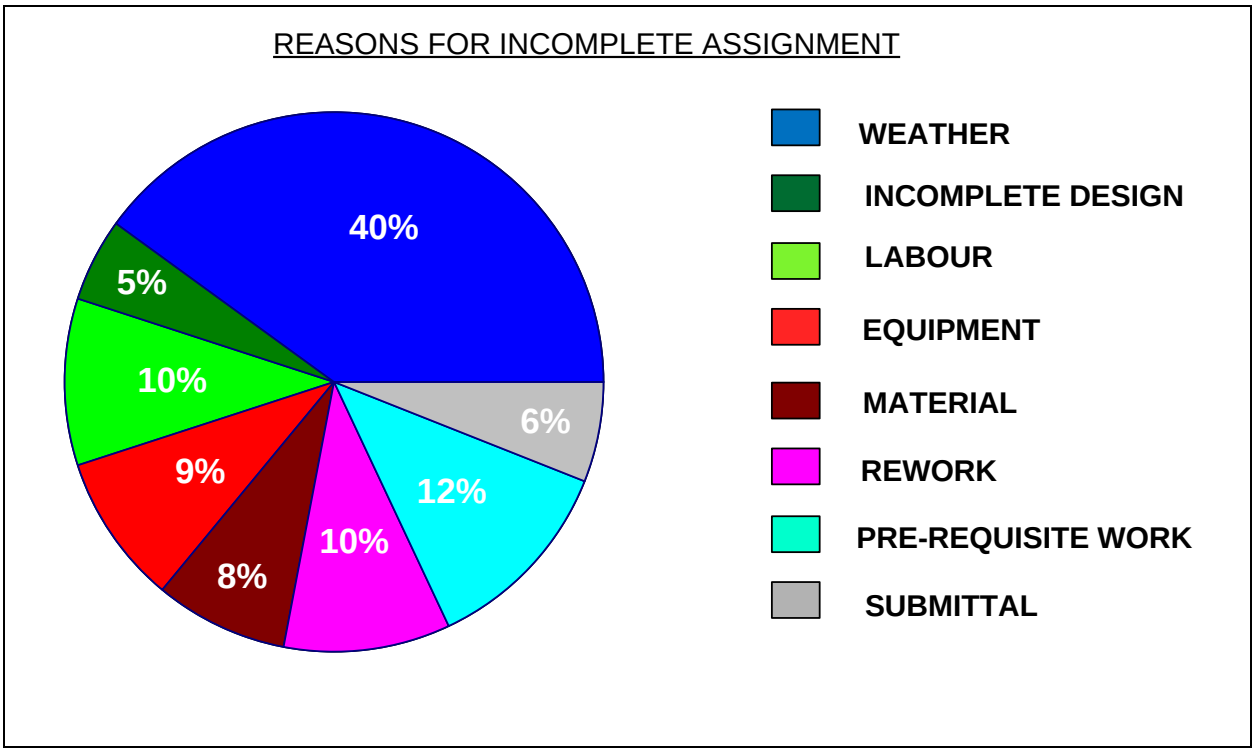


Figure 5.7 Reasons for incomplete assignment for third look-ahead schedule (24/9/12 – 21/10/12)

Most of the project participants became comfortable with the LPS implementation; they were aware of what to do and when to do each assignment. Although the major reason for incomplete assignment for this period was poor weather (40%). This was the peak of the raining season and work was suspended during days that had heavy rains and it was usually difficult to get labour to work during rains.

Other reasons for incomplete assignments included pre-requisite work (12%), rework (10%), labour (10%) and equipment breakdown (9%), material unavailability (8%), submittals (6%) and incomplete assignments (5%). It was however observed that the percentage of material unavailability as a reason for incomplete assignment dropped considerably from 26% to 8%. This was because the project participants in CRT4 had started receiving information promptly and regularly about possible constraints to the project and they had to remove these constraints

so tasks could be performed. However, the rains caused most of the planned tasks to be suspended and this resulted in workers waiting for tasks to be completed before another starts (i.e. pre-requisite work).

Finally, the PPC stabilised to an average of 86.67% at the fourth month. This is represented in table 5.8.

Table 5.8 Comparison of four weeks PPC (22/10/12 -18/11/12)

Weeks	No. of completed tasks	No. incomplete tasks	Total tasks	PPC
22/10/12 – 28/10/12	9	2	11	58%
29/10/12 – 4/11/12	10	1	11	50%
5/11/12 – 11/11/12	10	2	12	54%
12/11/12 –18/11/12	10	1	11	58%
	39	**6**	**45**	**87%**

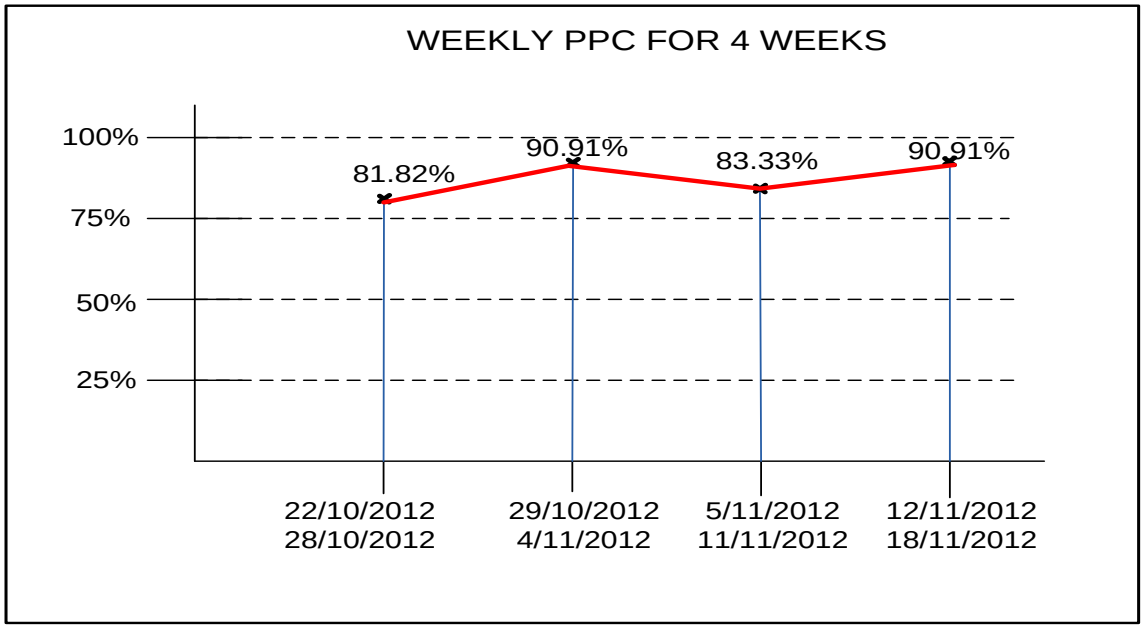


Figure 5.8 Weekly PPC for four weeks (22/10/12 -18/11/12)

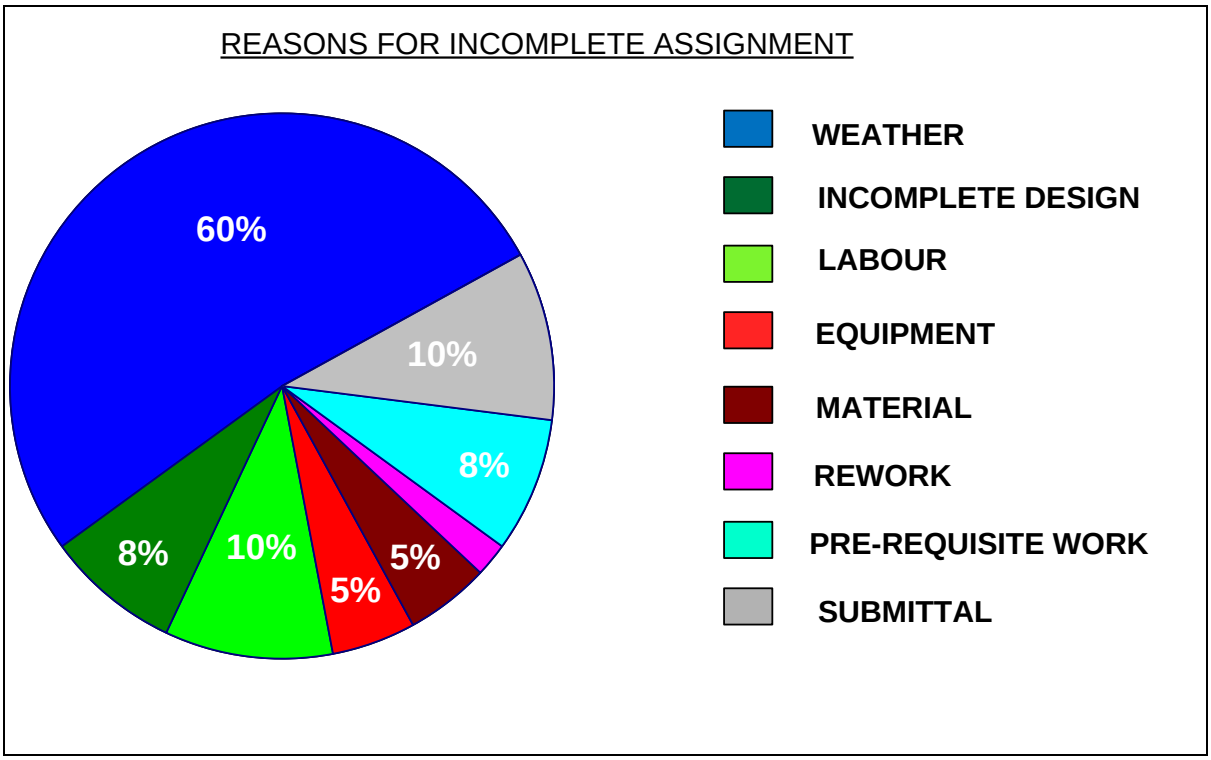


Figure 5.9 Reasons for incomplete assignment for fourth look-ahead schedule (22/10/12 - 18/11/12)

The enthusiasm of the project participants was very high and they were happy to collaboratively participate in the process. This motivation was because they were able to see the outcome of their commitments on a weekly basis. Form figure 5.9, the major reason for incomplete assignment was poor weather (60%), while the other reasons were; labour (10%), submittals (10%), pre-requisite work (8%), incomplete designs (8%) materials (5%) and equipment break down (5%).

5.9. PHASE 3 – POST IMPLEMENTATION

5.9.1. QUESTIONNAIRE SURVEYS

Questionnaire surveys were administered to the project participants to evaluate the LPS implementation process. The questionnaire was divided into four sections (section A –D), and the first section (section A) focused on getting an overview of the outcome of the

implementation. While the second section (section B) was on the barriers of the implementation and section C paid attention to the critical success factors of the implementation process. Furthermore, section D dwelt on the perceived benefits of implementing LPS on the case project. The respondents for the questionnaire comprised of the contractor team, the subcontractors and the suppliers. A percentage breakdown of the respondents is shown in Table 5.9 and the details of the questionnaires and their corresponding responses are discussed below.

Out of the 35 stakeholders involved in the survey 34 (97%) provided responses accordingly. Out of the respondent, 23 (68%), 7 (20%) and 4 (12%) are respectively contractor team, subcontractors and suppliers.

Table 5.9 Respondents of the questionnaire for Case Study 1

RESPONDENTS Total	34	100%
Contractor Team	23	68%
Subcontractor	7	20%
Supplier	4	12%

SECTION A

The question on whether LPS was very effective within the project was examined by the 34 respondents under the 5- point likert scale. The proportion of those accepting the effectiveness of LPS within the project is 82%, against 18% that neither agreed nor disagreed.

Furthermore, it was identified that 100% of the respondents agreed that compared to their previous projects the results were satisfactory. In the same vein, the question on whether the weekly work plans or PPC's were useful to the implementation was carefully examined, 76%

respondents agreed on the usefulness of weekly plans and PPC while the remaining 24% respondents were indifferent or disagreed.

Additionally, from the survey results only 26% of the respondents felt that the process of implementing LPS was difficult. However, the remaining 74% felt it was easy carrying out implementation.

In summary of the section A and judging from the proportion of responses obtained from each question, we can conclude that a significant proportion of the respondents agreed to the effectiveness of the LPS and that the results obtained from the implementations were satisfactory. Similarly, a large proportion also attested to the usefulness of WWP and PPC. However, a significant proportion agreed that it was difficult implementing LPS on the project.

Table 5.10 Overview of the implementation (Section A) Case Study 1

s/n	Reasons	weighting frequency (f)									
		1	**2**	**3**	**4**	**5**	$\sum f$	$\bar{x}$	**RII**	**RANK**	**%Rating**
1	*LPS was effective*	0	0	6	21	7	34	4.03	0.81	2nd	82%
2	*Results obtained were satisfactory*	0	0	0	24	10	34	4.29	0.86	1st	100%
3	*WWP & PPC was useful*	0	1	8	18	7	35	4.01	0.80	3rd	76%
4	*Difficulty in carrying out the implementation*	9	12	4	9	0	34	2.03	0.41	4th	26%

Table 5.11 Barriers during the implementation (Section B) Case Study 1

s/n	Barriers	weighting frequency (f)									
		1	**2**	**3**	**4**	**5**	$\sum f$	$\bar{x}$	**RII**	**RANK**	**%Rating**
1	*Poor supervision & quality control*	3	7	11	12	1	34	3.03	0.61	6th	38%
2	*Fluctuations & variation*	0	4	8	21	1	34	3.36	0.67	5th	65%
3	*Subcontractors involvement*	0	7	5	20	2	34	3.50	0.70	4th	65%
4	*Resistance to change*	0	0	1	30	3	34	4.05	0.81	1st	97%
5	*Cultural issues*	0	2	4	21	7	34	3.97	0.79	2nd	82%
6	*Lenghty approval*	2	1	11	14	6	34	3.62	0.72	3rd	59%

Table 5.12 Critical success factors to the implementation (Section C) Case Study 1

s/n	Factors	weighting frequency (f)									
		1	**2**	**3**	**4**	**5**	$\sum f$	$\bar{x}$	**RII**	**RANK**	**%Rating**
1	*Training & empowering last planners*	0	0	0	30	4	34	4.12	0.82	2nd	100%
2	*Team work*	0	2	11	17	4	34	3.68	0.74	6th	62%
3	*Motivating people to make changes*	0	0	1	30	3	34	4.06	0.81	3rd	97%
4	*Appropriate human capital*	0	7	20	5	2	34	3.06	0.61	7th	20%
5	*Top management support*	0	0	0	15	19	34	4.56	0.91	1st	100%
6	*Managing resistance to change*	0	2	12	10	10	34	3.82	0.76	4th	59%
7	*Close relationship with suppliers*	0	1	9	20	4	34	3.79	0.75	5th	70%

Table 5.13 Benefits of the implementation (Section D) Case Study 1

s/n	Benefits	weighting frequency (f)									
		1	**2**	**3**	**4**	**5**	$\sum f$	$\bar{x}$	**RII**	**RANK**	**%Rating**
a	*Solve problems on time*	0	0	2	25	7	34	4.15	0.83	2nd	94%
b	*Reduces bad news*	0	0	5	20	9	34	5.00	1.00	3rd	85%
c	*Reducing load on management*	0	8	11	8	7	34	3.41	0.68	10th	44%
d	*Predictable & reliable work plan*	1	4	13	9	7	34	3.76	0.75	7th	47%
e	*Projects are safer, faster and within cost*	0	8	5	16	5	34	3.53	0.71	9th	62%
f	*Stabilises projects*	0	0	11	16	7	34	3.88	0.78	5th	68%
g	*Improves logistics*	1	0	5	23	5	34	3.91	0.78	4th	82%
h	*Improves predictions of labour*	1	1	13	9	10	34	3.76	0.75	6th	56%
i	Reduces risks	0	3	13	10	8	34	3.68	0.74	8th	52%
j	completes project on schedule	0	0	0	27	7	34	4.20	0.84	1st	100%

SECTION B

The question in this section centred on the barriers faced during the implementation. The questions were formatted using a 5-point likert scale for each attribute attached to the question. The attributes were divided into 6 options identifying possible barriers to the LPS implementation. Table 5.11 and Figure 5.10 combined shows a holistic description of the responses, although figure 5.10 showing their views on a bar chart.

From table 5.11, it was observed that 38% agreed to the option that supervision/quality control was a barrier to the implementation, while 65% were of the opinion that fluctuations and variations were barriers during the implementation. Furthermore, 65% indicated that subcontractor's involvement was a barrier faced by the company during the implementation.

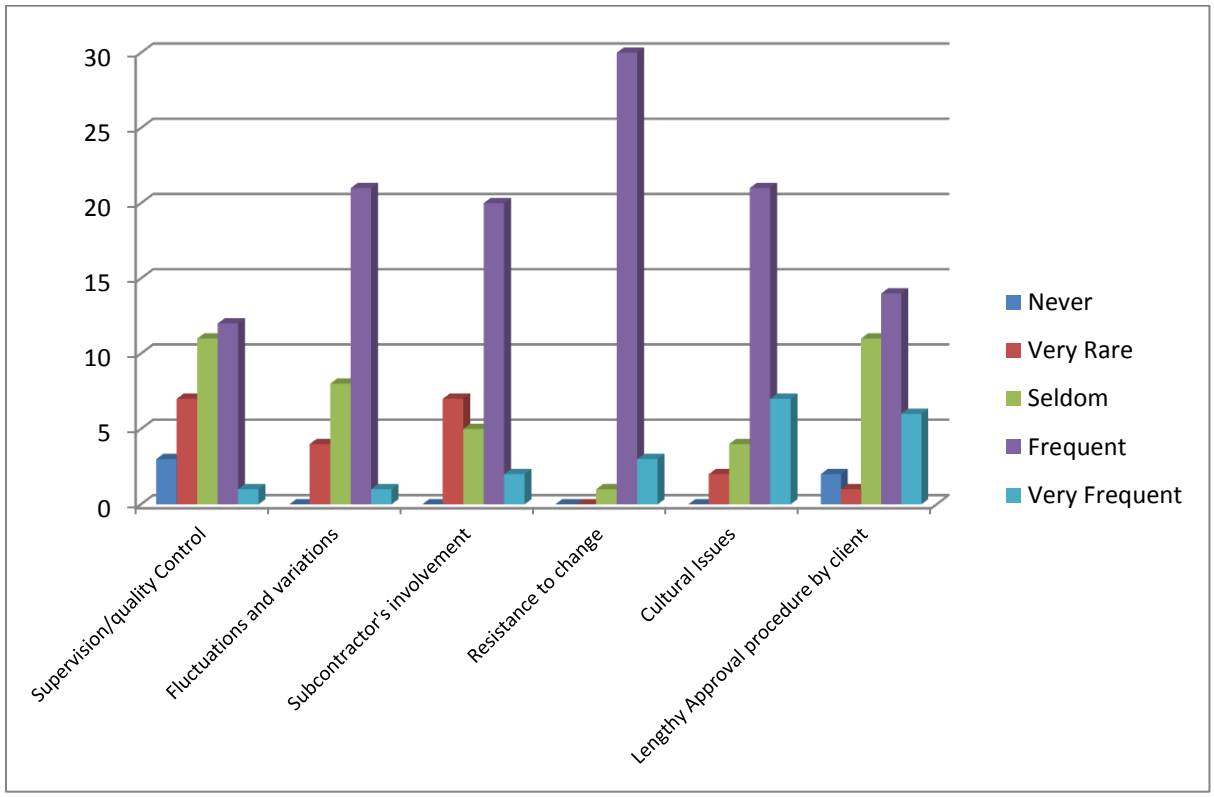


Figure 5.10 Barriers during the implementation of LPS in Case Study 1

In the same vein, 97% agreed that resistance to change was a major barrier. While another 82% were of the opinion that cultural issues was a barrier. Finally, 59% agreed that lengthy approval procedure by the client was a barrier to the implementation process. In other words, supervision/quality control could be said to be a minimal barrier while, subcontractor's involvement, resistance to change, cultural issues, lengthy approval procedure by clients and 'fluctuation and variations' can be said to constitute the major barriers faced by the company during project implementation.

SECTION C

This section evaluates the critical success factors of implementing LPS within this case study. The attributes for the question raised in this section, were possible success factors derived from the literature reviews and from the site observations during the implementation. Tables 5.12 and Figure 5.11 shows the views of the respondents.

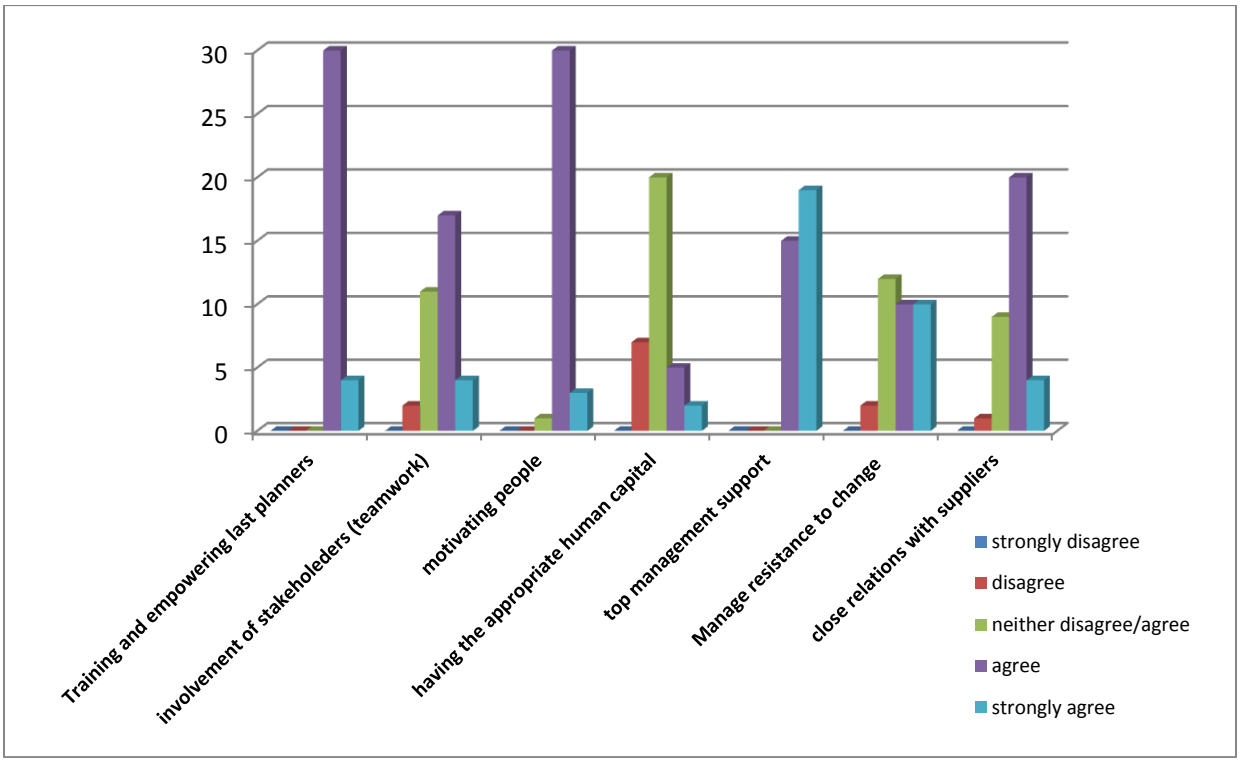
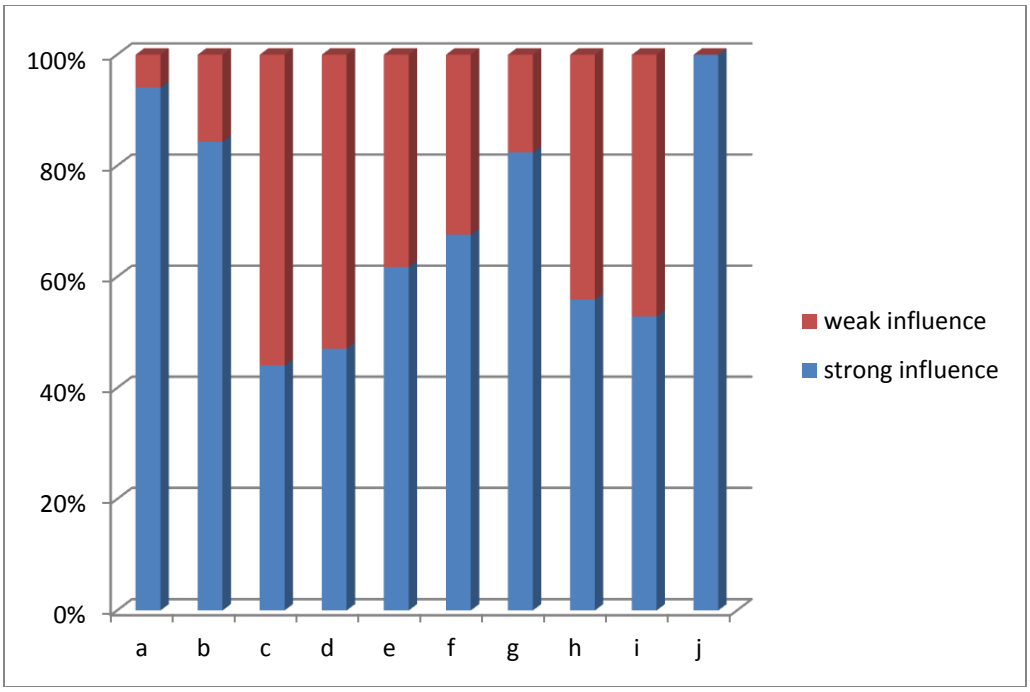


Figure 5.11 The Critical Success Factors to the implementation of LPS in Case Study 1

Here, 100% respondents agreed that training and empowering last planners were a critical success factor (CSF) to the implementation. In the same vein, 62% respondents agreed that involvement of all stakeholders (i.e. team work) was a major CSF to the implementation. Similarly, 97% were of the opinion that motivating people was a CSF to the process, while 100% affirmed that top managements support was one of the critical success factors. On the other hand, 59% indicated that managing resistance to change was a CSF. Similarly, 70% agreed that having a close relationship with suppliers was a CSF for the implementation. Conversely, only 20% of the respondents were of the opinion that having appropriate human capital was a CSF, while the remaining 80% respondents were either indifferent or disagreed that having appropriate human capital was a CSF.

SECTION D

This section focused on the benefits of implementing LPS. Ten benefits were suggested as possible benefits of implementing LPS and respondents were expected to express their views by indicating there levels of agreement in a 5-point likert scale. Table 5.13 shows the responses gathered from this section, and the frequency of influence the perceived benefits had on the project.



a= Identifying & addressing potential problems before they become obstacles in the project
b= Reducing the incidence of bad news & to get what bad news there is early
c= Developing supervisory skills and reducing the load on management
d= Creating a more predictable & reliable production program
e= Delivering projects more safely, faster & at reduced cost
f= Stabilizes projects & support other lean actions
g= Improving construction logistics on projects
h= Improving predictions of labour required
i= Reduces the risk of catastrophic loss
j= Completes projects on schedule

Figure 5.12 Benefits of implementing LPS in Case study 1

It was observed that 94% of the respondents agreed that LPS identifies and addresses potential problems before they become obstacles. In the same vein, 85% agreed that LPS reduces the incidence of bad news and completes project on schedule. However, only 44% of the respondents accepted to the benefits that LPS develops supervisory skills, reducing the load on management. Similarly, only 47% accepted that LPS creates a more predictable and reliable production program, with the remaining 53% disagreeing.

62% agreed on LPS's ability to deliver the project more safely faster and at a reduced cost while 15% and 23% were indifferent and disagreed respectively on this opinion. Similarly, 68%

admitted that it stabilises projects and support other lean actions, while 82% identified that LPS had the potential to improve construction logistics on projects.

Additionally, 56% respondents indicated that LPS has the benefit of improving predictions of labour required within any project. However, 52% agrees that it is able to reduce the risk of catastrophic loss while 48% disagreed on this opinion Finally 100% respondents agrees on its ability to complete project on schedule.

5.10. COMAPARISON OF THE FOUR PROTOTYPE HOSTEL PROJECTS

Comparing the outcomes of the four projects, it was observed that CRT 4 i.e. the fourth contractor, produced substantial results in terms of time cost and quality performances. The contractor finished the project two months earlier than the completion date allocated to the project, though the project kicked off three months late.

In comparison the first contractor CRT1 who completed his project 5 months late and the second contractor CRT2 completed the project 6 months while the third contractor (CRT3) couldn't complete the project but abandoned it due to cost overruns.

On the other hand CRT 4 had a better allocation of resources, an organized flow and access of materials and this reduced interference amongst working teams. Making each team members were aware of what to do and when to do each assignment.

Although the four projects suffered from material shortages, the problem of Material shortage was overcome by the fourth contractor by engaging in short term and Look ahead planning together with regularly doing a constraint analysis to envisage possible constraints to the project before they occur.

Implementing LPS helped the project team to receive information regularly of the project success and failures during weekly meetings.

5.11. CHAPTER SUMMARY

This chapter presents in substantial detail the process of implementing LPS in the construction of student's prototype hostel in Nigeria. The chapter described the phases of LPS implementation; these phases comprised of pre-implementation, implementation and post-implementation phases. The chapter also highlights barriers, Critical Success Factors and the perceived benefits recorded from the responses of the survey questionnaire completed by the project participants. From the PPC data recorded in this chapter, it was also revealed that material unavailability, pre-requisite work, labour supply, submittals, poor weather, rework, equipment breakdown and incomplete design information were all constraints faced within the project. However, implementing LPS by CRT4 was able to identify these constraints on time and it minimised the effect on the project compared to the other three contractors (CRT1, CRT2 and CRT3).

6. Chapter Six - CASE STUDY 2 (ROAD PROJECT)

6.1. INTRODUCTION

This case study examines the process of implementing LPS in a road and bridge construction project. This project was handled by an indigenous construction company in Nigeria. The project commenced during the last quarter of 2012 and continued till mid-2013.

The project entailed constructing a 4-Kilometer standard single carriageway road with sidewalks on both sides of the road and an 80 meters span bridge over river Ebeku to link up with an existing road. The pavement was proposed to have a total thickness of 450mm consisting of 150mm lateritic sub base; 150mm crushed stone base and 100mm asphaltic concrete and 50mm wearing course. The road works included earthworks and construction of side drains on one side of the carriageway. The total cost of the project is approximately 2.7 billion naira which is equivalent to 10 million British pounds. The expected completion duration was eight months.

The project was a unique one, and this was as a result of the existing terrain of the area. The terrain was gently sloping or near flat and it was typical of the Niger Delta environment. The vegetation along and around the project was the coastal type of thick evergreen tropical rain forest, comprising of palm trees, coastal grasses, cassava farmlands etc. Geologically, the entire road alignment lies within the 'Back Swamp' of the coastal plain sand of the Benin geological formation. Benin formation is the most recent of the three lithostratigraphic units (i.e. Benin, Agada and Akata formations) of the Niger delta (Amajor, 1991).

The project was one of the developmental projects of the Niger Delta Development Commission (NNDC) of the Federal Republic of Nigeria. NDDC was established with a mandate to bring about a rapid sustainable development of the Niger Delta region of Nigeria.

6.2. CASE HISTORY

The contractor handling this project participated in a series of workshops on Last Planner System (LPS) and Lean construction. The workshops were organised by the researcher as part of the research program. They were organised in conjunction with both the NDDC and NSE (Nigerian Society of Engineers). During the workshop; the concepts of Lean Construction and the benefits to be derived from LPS intrigued the contractor, especially when the contractor realised that LPS helps deliver bad news early before it becomes a major issue; creating predictable and reliable production programs; minimising project cost and delivering projects faster.

The contractor being a small scale indigenous contractor identified that his previous construction projects (both roads and buildings), were always completed above the project budget. In addition, the contractor also reported that he had to abandon some of the project in some cases as they usually ran behind schedule. He was however excited with the idea of implementing LPS with this project.

6.3. CASE DESCRIPTION

The project involved both the construction of an access road and a bridge (as already pointed out). The road segment entailed pre-fill surveys, clearing, fillings, compaction and scarification, priming and asphalting. While the bridge section entailed retaining walls, abutments, erosion control works and pilings.

6.3.1. PRE-FILL SURVEY

The Pre-fill surveys commenced while mobilisation of equipment to the site was in progress. The team of surveyors led by the senior surveyor carried out some preliminary survey works in order to determine the followings; the right of way, the level of cut and fill to be carried out, the

establishment of the transition curves (horizontal and vertical curves) and the road profile. Chainages were marked out at 20m intervals while the right of way of 30m was set out and marked with wooden pegs painted white. The whole exercise lasted for a period of two week for the entire 4km road.

6.3.2. CLEARING

Clearing activities progressed with the aid of the company's dozer (D6). This was used in clearing the roadway of all bushes, shrubs and trees as the case may be. The right of way was maintained as pegged out by the surveyors to the width of 30m stipulated in the BEME (Bills of Engineering Measurement and Evaluation).

A period of three weeks was used in carrying out clearing because of the breakdown experience in the machine while in operations. The spoils / cross-cuts were carted away by the use of a pay loader and trucks to a used borrow pit as directed by the resident engineer. However, borrow pits were sourced for and acquired and they were located at places not more than 5km from the road under construction. Soil samples were taken to a soil laboratory where the necessary tests were conducted.

6.3.3. FILLING

For the fillings, laterite materials were hauled with trucks from the borrow pit, and this activity commenced after the laboratory tests were concluded with the results showing that the materials were suitable for filling. The laterite materials were stockpiled in reasonable quantities using pay loaders. Graders on the other hand were used to do the grading and spreading of the stockpiled materials along the entire road. The filling lasted for approximately nine weeks, with setbacks from the community disturbances during haulage.

6.3.4. COMPACTION AND SCARIFICATION

Compaction of the graded laterite was carried out to 100% BS. This was however done in layers of 150mm by vibrating rollers. The entire roadway was cambered according to specification. Compaction tests were done at every 200m interval, while scarification, watering, grading and additional compaction of the entire surface were done in stages and this lasted for four weeks; this was followed by the preparation of the surface of road base to receive the prime coat

6.3.5. PRIMING

The road surface was swept clean while the MC1 was being heated to the required temperature of 120^0c by the tar-boiler. Thereafter it was sprayed on the surface at the rate of 1.litre per m^2. However, this was done after the surveyor had pegged out the width of the road (10.3m) to be primed.

Furthermore, after about 15-20 minutes of the priming, blinding with sharp river sand was carried out. The priming process was carried out in two weeks for the span of the entire road.

6.3.6. ASPHALTING

The primed surface was swept clean of sharp sand. The carriageway was marked out with pegs at a distance of 1km. This was followed by the application of approved tack coat using colas 'A' at a rate of 0.5m per square meter and it was done manually with the aid of spraying cans. This application of colas 'A' was done just before the commencement of the asphalting so asphalt would bond with the primed surface.

The thickness of the asphalt was 100mm in accordance with the specification. Between 15-20min after the asphalt was laid, asphalt rollers (steel and tyre) were used to compact and smoothen the surface while it was watered by the rollers. The width of the asphalted surface was

7.3m. This was followed by asphalting of the 50mm wearing course. The entire asphalting of both the binder and wearing course lasted for of two weeks.

6.3.7. BRIDGE WORKS

The proposed reinforced bridge is 11.0m wide deck, and would be made up of 8.0m trafficked roadway and 1.30m raised walkway on both sides of the road. The abutment and piers are founded on reinforced concrete bored piles of 1300mm diameter. The abutments are conventional counter-fort with return walls. The piers are 1000m reinforced concrete wall for free flow and navigation of marine vessels, particularly during the periods of high water level. The bridge construction was given to a subcontractor who was a specialist on bridge construction.

Figures 6.1a to figure 6.6 below shows some images from the road and bridge construction already described above.

Figure 6.1 Clearing of the road

Figure 6.2 Grading of the road

Figure 6.3 Asphalting of the road

Figure 6.4 Finished road surface

Figure 6.5 Construction of the bridge abutment

Figure 6.6 Construction of Bridge Piers

6.4. RESEARCH ACTIVITIES AT THE SITE

The research activities commenced with non-participant observations around the construction site for one week. An observation of how site activities were planned, managed and controlled was carried out. This observation gave the researcher an insight to the current planning practice. Furthermore, the researcher carried out three interviews at different times, one with the project manager and two interviews with the site engineer from both the contractor handling the project

and the client representative. This was followed by an introductory workshop on Lean Construction and LPS. The researcher gained the approval of the company management to go through the LPS process with the project participants. The participants were mainly from the contractor team with a representative for the clients and consultant and a few suppliers (especially the asphalt and 0-50 suppliers). It was however observed that the major subcontractor who was handling the bridge project was absent.

During the introductory workshop which held on 16 November 2012 by 9:00am at the site premises. It commenced with an introduction and an overview of Lean construction and LPS. The researcher explained the advantages of Lean construction and supported the advantages with practical case study projects. The researcher then delved into Lean Construction related tools and techniques. This was where LPS was introduced and more insight on how to implement LPS within projects were explained.

Furthermore, make-ready forms and look-ahead plans were distributed and explained, PPC calculations and other technical issues also discussed. The researcher then took the participants through a demo project and everyone participated filling out the forms and calculating the PPC's. This interactive session created an enthusiasm among the project teams as they were all ready to implement the LPS within the road project.

At the end of the interactive sessions and workshop, the researcher and the entire project participants decided to break the project process into four chronological spans/stages. The spans are shown below in Figure 6.7

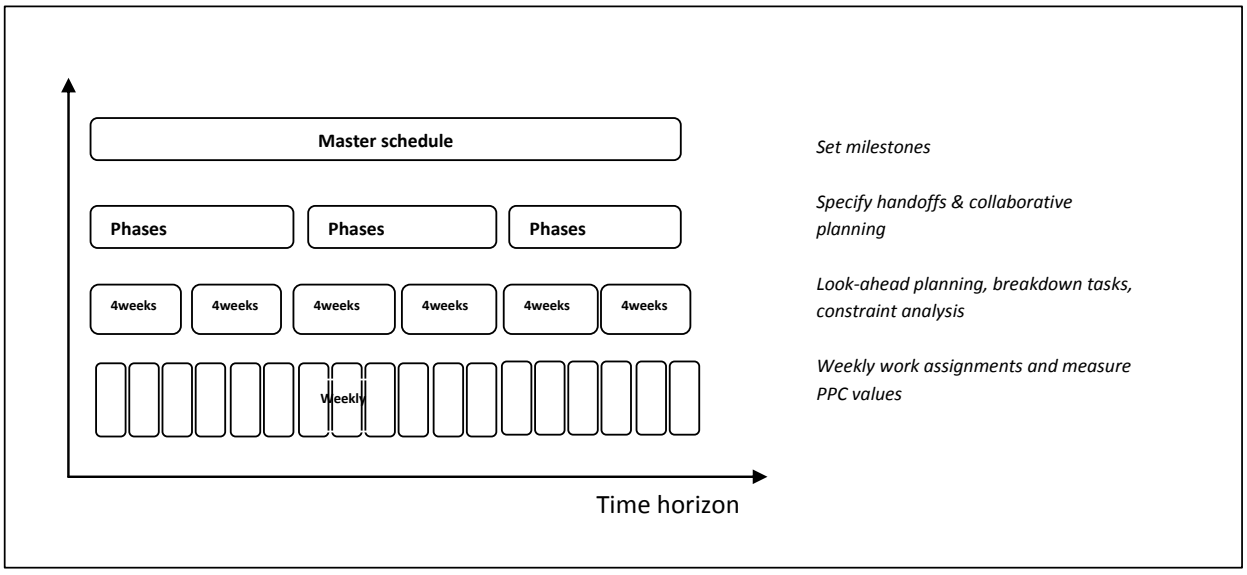


Figure 6.7 Chronological spans for the project

The first span was the **master schedule** where the milestones for the entire project were set. This was the output of the front-end planning for the entire project. It described the work to be carried out over the entire duration of a project. The second span was the **Phase scheduling**. This was to generate a detailed schedule for each project phase. While the third span of the project was the **Look-ahead planning**; at this span tasks were broken down into 4 weeks, with responsibilities assigned to each task and the constraints affecting the tasks identified. The fourth span which was the most detailed of the four spans was the **weekly planning;** here it was agreed that at the end of every week assignments will be measured and reviewed to measure the reliability of planning and the production system. Furthermore the reasons for plan failures will also be analysed weekly and the reasons used as the basis of learning and continuous improvement

The preceding week after the interactive sessions and workshop (week commencing from the 19/11/2012), some of the participants particularly the project manager, site engineer, supervisor equipment manager and consultant were interviewed on the existing planning and project management practice within the organisation. Some of the questions that were raised included;

planning and control mechanisms already in place for the project, involvement of other parties and stakeholders in the planning process and the communication channels in place (see Appendix 2B for the interview questions).

6.5. IMPLEMENTING THE LAST PLANNER SYSTEM

The research plan was to implement Last Planner System in four phase of the project. Details of this implementation as agreed with the project participants during the interactive session are discussed below.

6.5.1. THE MASTER PLAN

The master plan contains the milestone schedules. It outlined the general idea of the project, the main activities and execution time. The execution time was set in a manner that made it possible for those responsible for each activity to become confident that the work can be completed as planned. It was evident that the project manager for the contractor was used to the Critical Path Method (CPM), but was willing to incorporate the logic in CPM to identify major milestones from the master schedule. At this phase, project durations were set by the project manager in collaboration with the project engineer, the site engineer and the equipment manager.

6.5.2. PHASE PLANNING

During this phase, all the team members participated in developing a phase pull schedule for the different stages of the project, from the pre-fill surveys up to asphalting. The team members responsible for the work established the context, defined the milestone deliverable, developed an execution strategy, identified the tasks to be carried out and organised the teams to carry out these tasks. Hence, a face to face conversation was developed with team members agreeing on the hand-off criteria between activities and their corresponding durations. This was achieved by

the Last planner (the researcher) establishing major milestones for the different trades while the participants of this phase planning worked backward to achieve target completion date of these goals. At the end of this phase planning which started off on the 26th November 2012, the team members were confident that planned activities would have access to adequate resources and time to complete the work as planned.

6.5.3. LOOK-AHEAD PLANNING

The third phase of implementation started off on the 30th November 2012 with the first four-week look-ahead plan. It was the longest of all phases as it was linked to the fourth phase which continued to the end of the project. The Look-ahead planning was extracted from the Master Plan and the activities in the Phase planning established the tasks for the 4 week look ahead plans for each week. Sub tasks were created and linked to the Look-ahead plans. These were used to produce the project deliverables. However, tasks and the sub-tasks in the look-ahead plans were thoroughly screened for constraints by the responsible individual (the site Engineer acted was responsible for the screening) before reassigning the task to the last planner (the researcher acted as the last planner). Hence, Look-ahead plans were produced with the involvement of the project manager, project engineer, plant manager, the site engineers and the researcher. Constraint analysis was documented according to indications given by the project team and this analysis was performed jointly by all project members with the site engineer coordinating the analysis.

6.5.4. WEEKLY WORK PLANS

Within this phase, Look-ahead planning continued simultaneously with the weekly work plans. All the tasks in the Weekly Work Plan were in the Look-ahead plan and linked to the Phase plans. The Weekly Work plan was an update of the look-ahead plan and it maintained a six-week

widow continually. The plans were taken from the higher level schedule at a greater level of detail as shown in Figure 6.8

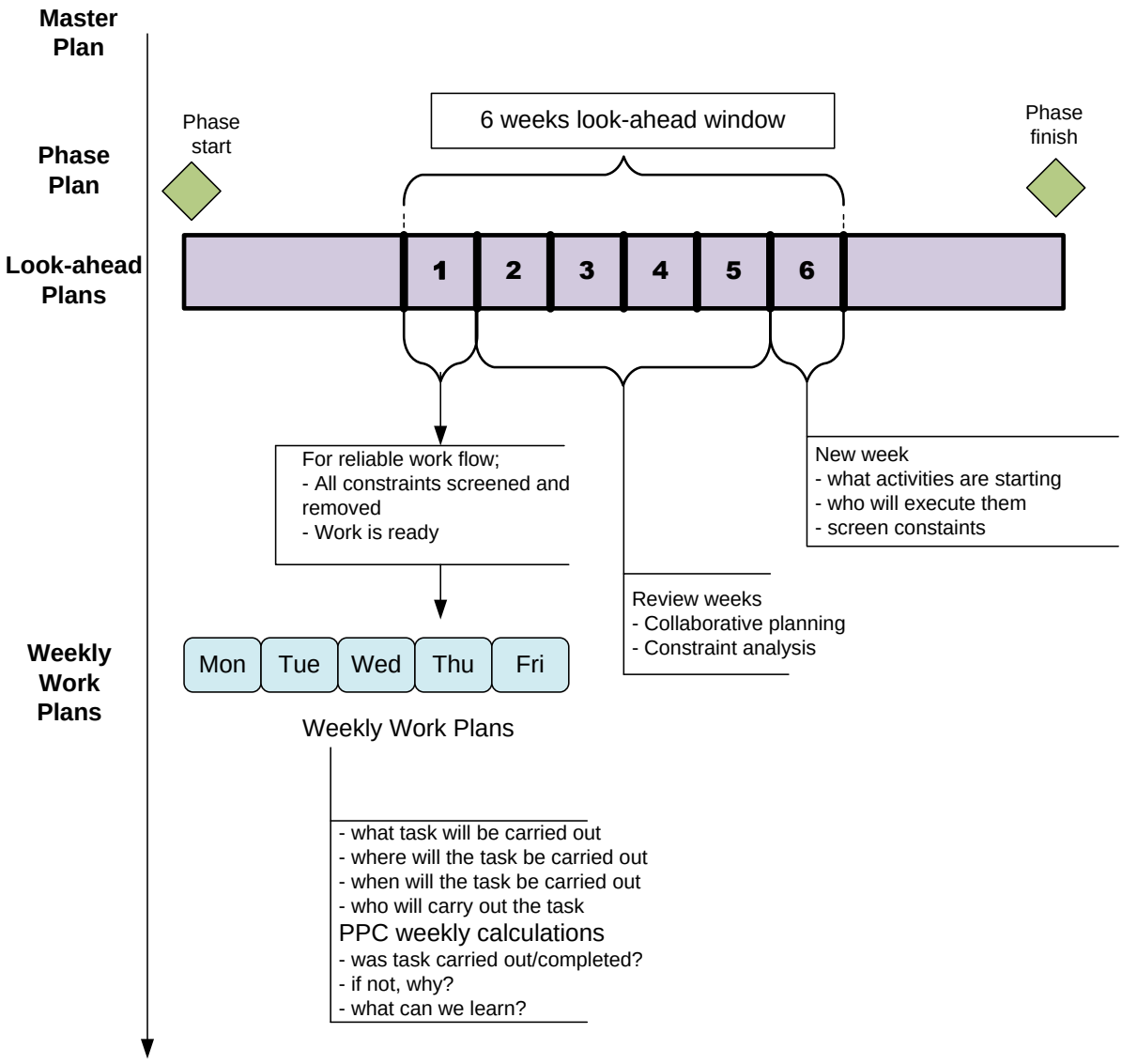


Figure 6.8 Preparation of the weekly work plans

The weekly work plans contained only tasks that are ready to be performed. This implies that all constraints that would have hindered the tasks have been removed. At the end of each week, the Percentage of Plans Completed (PPC) was calculated and the reasons for incomplete plans traced

and recorded. Full details of the PPC and the reasons for incomplete assignments are discussed in the next section of this work. At the start of this phase, 11th January 2013 the researcher had active involvement as the facilitator in the weekly meetings and in the preparation of the look-ahead plans. However, towards the middle of this phase 20th April 2013, the researcher reduced his presence at the site because the project teams had matured to the extent they could facilitate the process themselves. The researcher however attended the weekly meetings once a week to review the implementation process, calculate PPC's, analyse reasons for incomplete assignments and update the look-ahead plans

At the end of the four phases of the implementation, survey questionnaire were administered to evaluate the LPS implementation process. The aim of the survey was to allow all participants to report the usefulness of the LPS process and the barriers encountered during the implementation.

6.6. FINDINGS AND DATA ANALYSIS

The data gathered was in four different segments.

1. The non-participant observation
2. The interviews
3. The implementation and
4. The survey questionnaires

6.6.1. THE NON-PARTICIPANT OBSERVATION

It was revealed from the initial observations that there was no set out procedure to manage the site. The site engineer gathered the project team every morning to assign work packages for the day. The site engineer then reported to the project manager his daily work output while the project manager planned the next day's activities based on the report from the site engineer.

The back drop to this arrangement was that operators, subcontractors and suppliers did not know ahead of time what was planned out. This caused series of delays in the start-up process of the project. Similarly, at the initial stages of the project that did not require all the plants and equipment on site. However all the plants needed for the entire project (pavers, steel asphalt roller etc.) were already at the site prior to the full commencement of the project. The major equipment that was supposed to be at the site at the commencement stage of the project includes only bull dozers, pay-loaders and graders since the site clearance was only about to commence. This increased the overhead cost for the project as operators that were not carrying out any tasks soon were all at the site receiving their site allowances without carrying out any job. Whereas Lean Construction advocates for Just in time deliveries; bringing equipment to site when required, rather than creating waste from inventories. Nevertheless, it was observed that team-working was very evident at the site and responsibilities were well shared among the project team.

6.6.2. THE INTERVIEWS

From the interviews carried out, it was observed that there was no planning technique in place. The interview also addressed other matters such as the involvement of other parties in the planning process, the communication tools employed and the availability of frequent meetings during construction. The answers to the interviews provided a comprehensive account of the organisation's project management practice and the level of awareness of the importance of project management.

Details of the organisation's project management practice revealed that the project manager and the management team were motivated. They were made up of professionals who had good

experience on road construction and a little knowledge of project management concepts with no awareness of Lean construction.

Furthermore, from the interviews it was revealed that there was no special communication tool such Walkie Talkies or ICT tools (such emails and intranet or internet communication) available for the project. The project team relied mainly on verbal communication. Finally, meeting were held daily before start of work at site to brief the operators of their tasks and management meeting were held if any issues went wrong within the site.

6.6.3. THE IMPLEMENTATION

During the implementation of the last planner system, a lot of data was gathered. Different forms were completed on site by the project team, and these forms are found in Appendix 6 (6A-6E); they include the look-ahead schedule, constraints analysis charts, PPC chart and the reason for non-completion forms.

The look-ahead schedule and the constraint analysis chart were used to allow for the anticipation of future needs for materials, equipment and labour. They ensured tasks were ready to start when required with a certainty of labour, equipment and material requirements. The constraints identified during the constraint analysis were grouped under eight categories; contract, designs, submittals and documentation, operations, equipment, labour, weather and materials. This classification helped facilitate an enhanced co-ordination with the responsible persons resolving particular constraints identified.

The PPC charts and reasons for non-completion forms on the other hand were used throughout the implementation process. These reasons for non-completion were also subdivided into eight categories; contract, designs, submittals and documentation, operations, equipment, labour,

weather and materials. A weekly PPC's of 8 weeks was measured and is shown in Table 6.1 below.

The figure shows the PPC analysis for every 8 weeks within the project and at the end of the 8 weeks of measuring the PPC's, a meeting was held to evaluate the implementation process, discussing the lessons learnt from the implementation. In Table 6.1 and Figure 6.9 shows the measure of the PPC ranging from the week of 19th November 2013 to the week of 21ST January 2013. From the tables it is observed that no PPC was calculated for the week of 24th December 2012 and 31st December 2012. This was because the workers were allowed to go on Christmas holidays.

A Percent plan complete (PPC) is a measure of workflow reliability; the data required for PPC calculation are "the number of assigned tasks" and "the number of completed tasks" and this is calculated by dividing the number of tasks completed by the total number of tasks made for the plan period.

$$\text{PPC} = \frac{number\ of\ completed\ tasks}{Total\ number\ of\ tasks}$$

The Percentage of Plans Completed (PPC) started off low in the first few weeks. This was the first time that the project team was getting involved in implementing the Last Planner System and they were therefore not sure of what roles to play and how to keep promises and commitments. Similarly, some of the workers were also resistant to change and were sceptical about the benefits the implementation was going to offer. As the implementation progressed everyone felt comfortable and enjoyed the implementation, observing the benefits the system had on the project.

Table 6.1 Comparison of 8 weeks of PPC (19/11/12 – 21/01/13)

Start date for week	No. of completed tasks	No. of uncompleted tasks	Total activities/tasks	PPC
19/11/2012	5	6	11	45%
26/11/2012	8	6	14	57%
03/12/2012	10	4	14	71%
10/12/2012	9	6	15	60%
17/12/2012	8	3	11	72%
07/01/2013	8	2	10	80%
14/01/2013	6	1	7	86%
21/01/2013	6	2	8	75%
TOTAL	***60***	***57***	***90***	***67%***

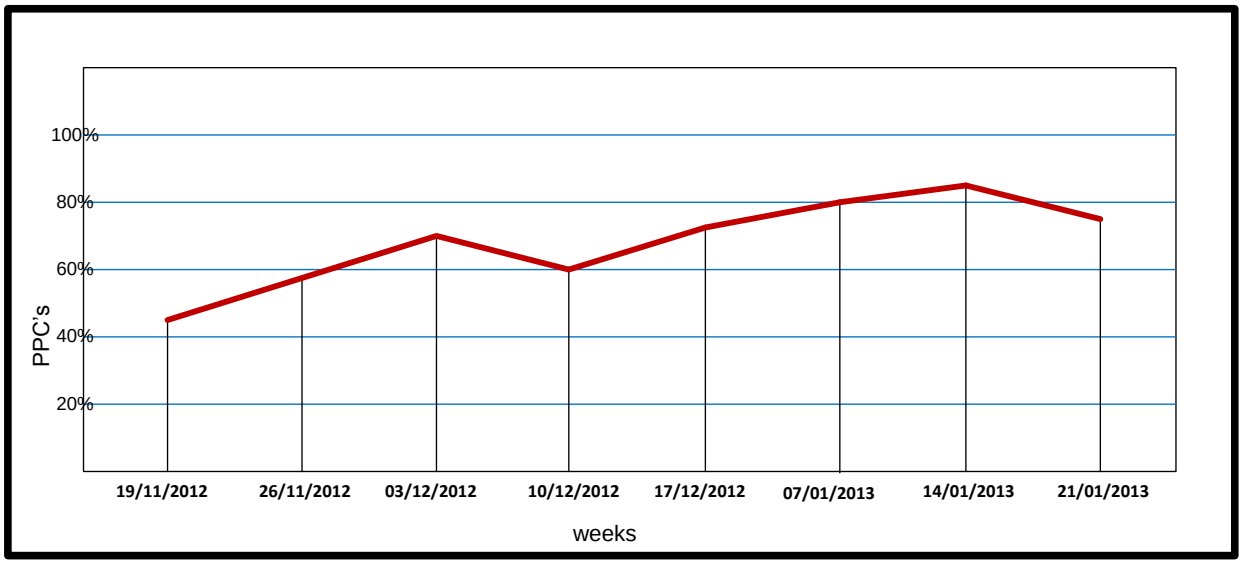


Figure 6.9 Weekly PPC's for 8 weeks (19/11/12 – 21/01/13)

Minutes of these meetings were documented and the aim of the meetings was to evaluate the implementation process during the 8-week period. It was observed that the involvement of all parties in the project was crucial for the success of the implementation process. Similarly, the reasons for incomplete assignments were analysed and documented for corrective actions to be taken during the next weekly meeting.

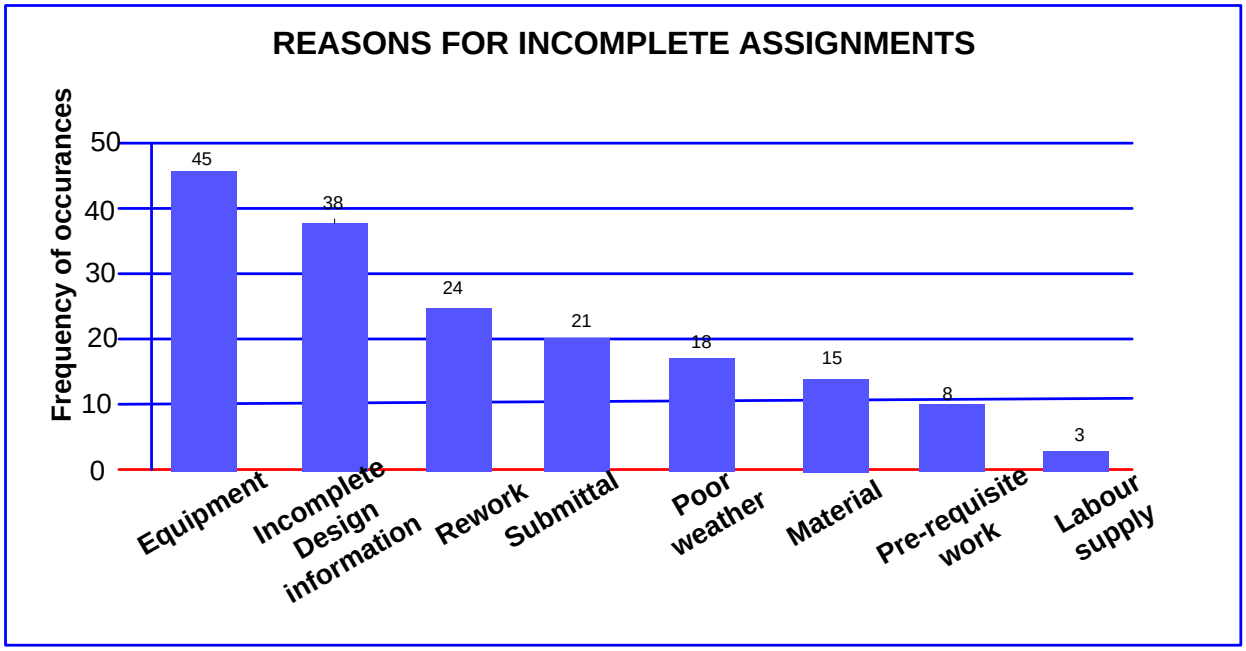


Figure 6.10 Reasons for incomplete assignments (19/11/12 – 21/01/13)

The reasons for the incomplete assignments within the 8-weeks are shown in Figure 6.10. The figure demonstrated that equipment break down was the most frequent reason for incomplete assignments. This was followed by incomplete design information; a lot of details were not included in the vertical and horizontal alignments designs. This made it difficult setting-out the project and calculating the levels for the cut and fill. In the same vein, this led to a lot of rework; which had the third highest frequency of 24. Other reasons for incomplete assignments included; submittals (late request), poor weather and materials unavailability, pre-requite work and labour supply. Although this analysis for incomplete assignments was limited to the category presented. Furthermore, weekly PPC's were calculated for next 16 weeks with an evaluation process carried out after 8 weeks for the 16th week of the project. The evaluation process basically evaluated the implementation process with the project team also discussed the lessons learnt from the implementation. Tables 6.2 and figure 6.11 shows the PPC measure for week commencing on

28th January 2013 to week commencing 18th March 2013 while Figures 6.11 shows the reasons for incomplete assignments.

Table 6.2 Comparison of 8 weeks of PPC (28/01/13 – 18/03/13)

Start date for week	No. of completed tasks	No. of uncompleted tasks	Total activities/tasks	PPC
28/01/2013	8	3	11	73%
04/02/2013	7	2	9	78%
11/02/2013	9	4	13	69%
18/02/2013	9	3	12	75%
25/02/2013	8	3	11	73%
04/03/2013	10	2	12	83%
11/03/2013	11	4	15	73%
18/03/2013	9	3	12	75%
TOTAL	***71***	***22***	***93***	***76%***

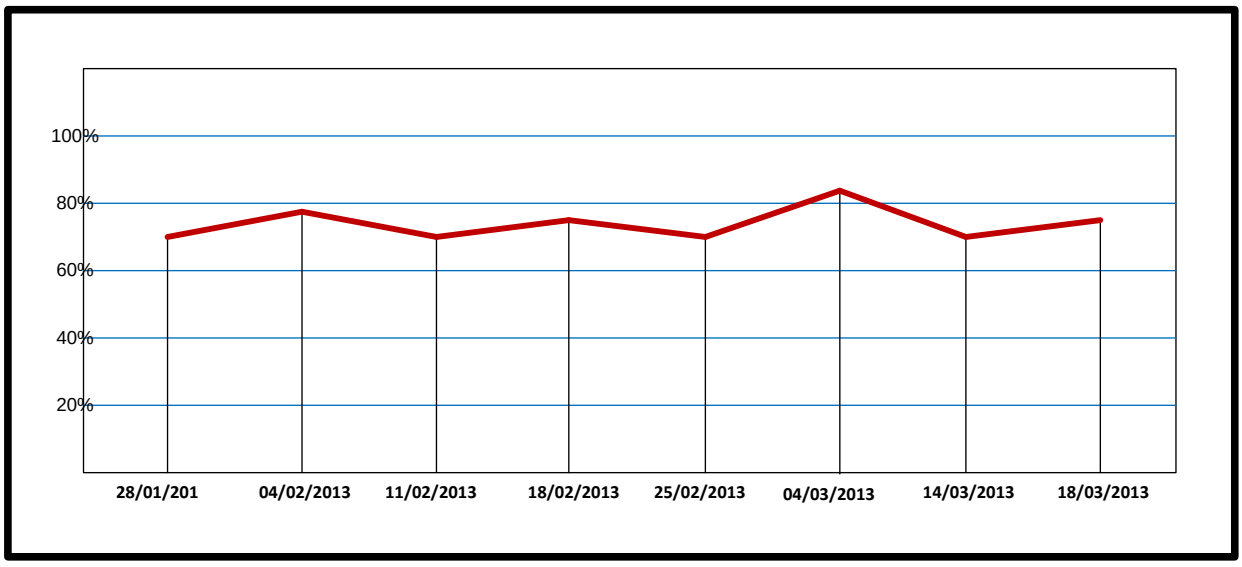


Figure 6.11 Weekly PPC's for 8 weeks (28/01/13 – 18/03/13)

From Tables 6.2 and Figures 6.11 it is observed that the average PPC within this period was 76% which was a remarkable improvement from the previous evaluation whose PPC was averaged at 67%. In addition, the highest PPC value of 83% was recorded on the week commencing from the

4th of March 2013, while the lowest PPC value of 69% was recorded on the week of 11th February 2013.

Furthermore, the reasons for the incomplete assignments within these 8-weeks are shown in Figure 6.12. It was identified that pre-requisite work was the most frequent reason for incomplete assignments and delays as a result of waiting for a task to be completed before another starts. This was basically because of the nature of the stage that the project had reached; i.e. this was the stage where most of the activities were dependent on the earth works. Particularly the compaction of the graded laterite in layers of 150mm by vibrating rollers; the compactor had to wait for the stock-piled materials to be spread along the road. However the site engineer had to stockpile the laterite materials to avoid setbacks experienced from community disturbances being experienced during haulage of the laterite materials.

In the same vein, the compacted surfaces had to be scarified and compacted over and over again and this rework was affecting the completion of assignments planed. This rework was also recorded in Figure 6.12 as the second highest percentage of uncompleted assignments. The third reason given was the un-availability of materials. This was because of community disturbances from the youths around a neighbouring community; this community was the only access to the project site and suppliers delivering materials to the site were delayed until government officials had to step in to resolve the situation.

The fourth major reason for incomplete assignments was equipment break down. This was followed by incomplete design information; especially during the construction of the side drains which was carried out within this phase. Similarly, details of the fill levels were not indicated hence the surveyors had to establish one. Other reasons for incomplete assignments included; poor weather, submittals (late request) and labour supply.

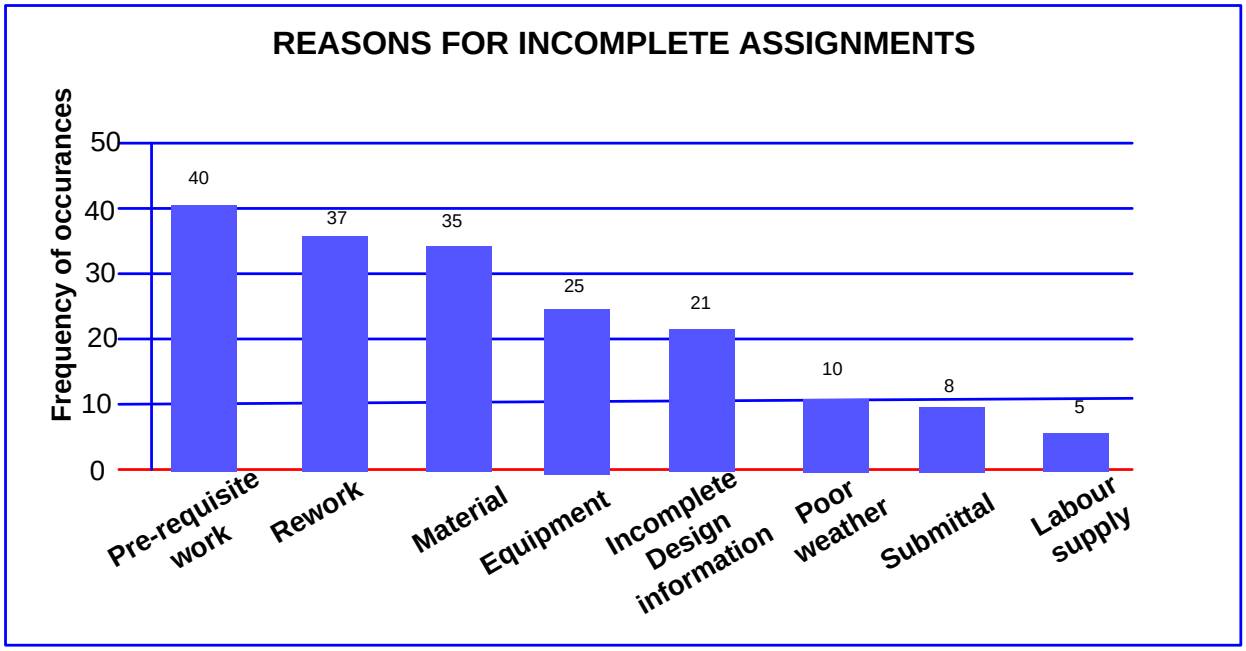


Figure 6.12 Reasons for incomplete assignments (28/01/13 – 18/03/13)

Finally, for the remaining 8 weeks to make up 24 weeks of the LPS implementation weekly PPC's were calculated and an evaluation carried out at the end of the 8 weeks. The project team discussed the lessons learnt from the implementation and evaluated the entire implementation process. Tables 6.3 and Figure 6.13 shows the PPC measure for week commencing on 25th March 2013 to week commencing 13th May 2013 while Figure 6.14 shows the reasons for incomplete assignments.

Table 6.3 Comparison of 8 weeks of PPC (25/03/13 – 13/05/13)

Start date for week	No. of completed tasks	No. of uncompleted tasks	Total activities/tasks	PPC
25/03/2013	9	3	12	75%
01/04/2013	8	2	10	80%
08/04/2013	7	2	9	78%
15/04/2013	6	3	9	67%
22/04/2013	5	1	6	83%
29/04/2013	5	2	7	71%
06/05/2013	6	2	8	75%
13/05/2013	7	1	8	88%
TOTAL	***53***	***16***	***69***	***77%***

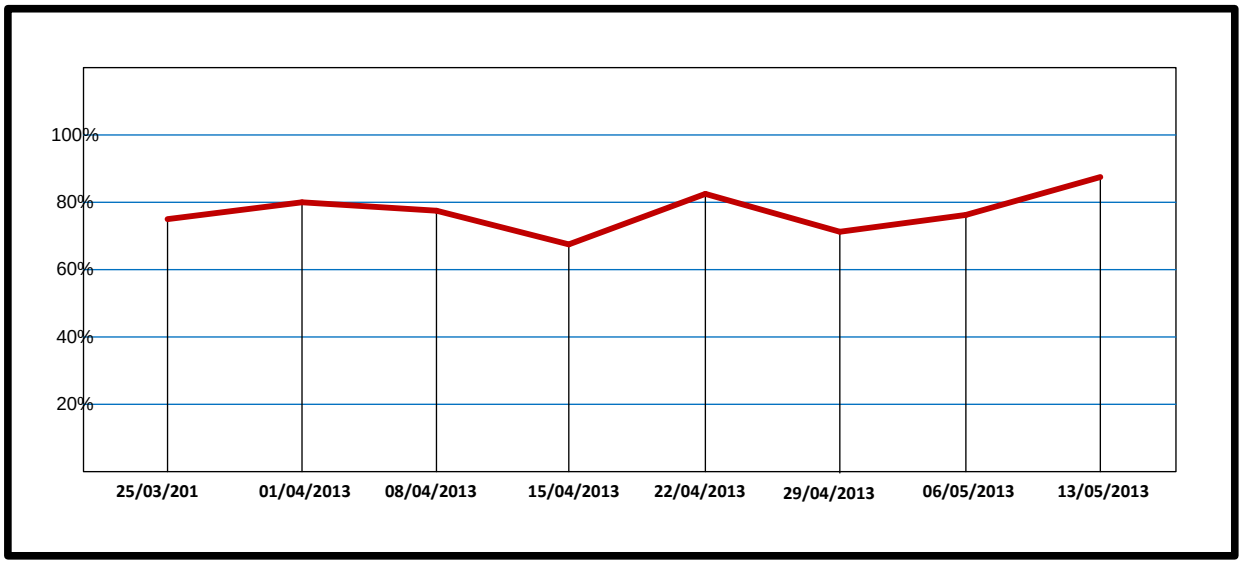


Figure 6.13 Weekly PPC's for 8 weeks (25/03/13 – 13/05/13)

From comparison of the 8 weeks PPC in Tables 6.3 and the chart of the weekly PPC's in figures 6.13 it is observed that the average PPC within this period is 77%. This stage of the project had just rounded up earth works while priming and asphalting commenced. It was recorded that the highest PPC value of 88% was recorded on the week commencing from the 13th May 2013. Major activities carried out within that week were the pavement works consisting of lateritic sub base, crushed stone base and asphaltic concrete. However, the lowest PPC value of 67% was recorded on the week of 15th April 2013; the major setback on the project within that week was poor weather.

The reasons for the incomplete assignments within these 8-weeks are shown in Figure 6.14

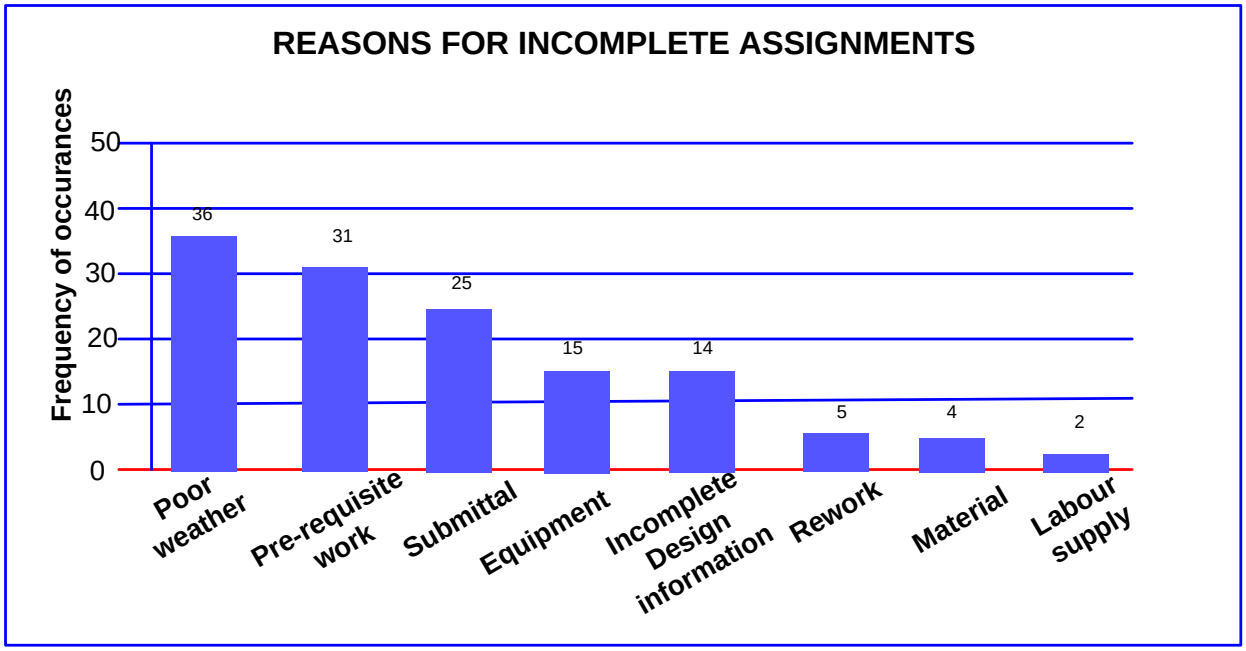


Figure 6.14 Reasons for incomplete assignments (25/03/13 – 13/05/13)

The reasons for the incomplete assignments were captured in Figure 6.14. It was observed that poor weather was the major reason for incomplete assignments within this phase and it had a chain effect of affecting pre-requisite work. The rains poured out heavily and caused most of the tasks to be suspended and this resulted in workers waiting for task to be completed before another starts. Similarly, submittal (late request) was the third highest reasons for incomplete assignments; and it resulted in delays as requests were submitted too late for decisions to be made that would enable particular activities to start on time

The fourth major reason for incomplete assignments was equipment break down. This was followed by incomplete design information; especially while constructing the pavements. Other reasons for incomplete assignments included; defects requiring rework, material unavailability and labour supply.

6.6.4. ANALYSIS OF THE PPC CHARTS FOR THE 3 PHASES (24 WEEKS OF 8 WEEKS EACH)

The average PPC's for the entire implementation period was 73%, with the highest PPC at 88% and the lowest at 45%

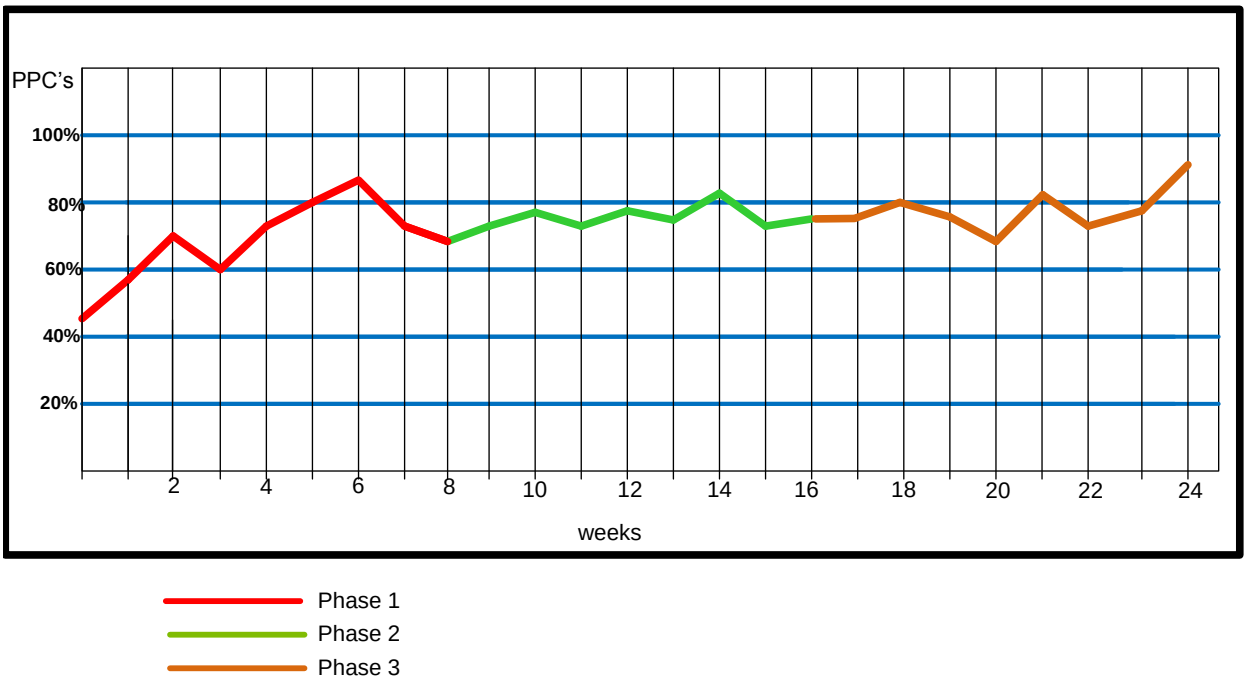


Figure 6.15 Comparison of Weekly PPC's for the three phases

The three project phases in which the Last planner System was implemented was dependent on another and it was a continuous process, however, a comparison is drawn for the three phases (24 weeks of 8 weeks each)**.** From the assessment as depicted in Figure 6.15, after the PPC's stabilised for Phase 2 and Phase 3, the project participants became familiar with the implementation process. They showed great enthusiasm to learn and improve the project hence improvements recorded in phase 2 and 3. Similarly in phase 1, it was observed that after 2 weeks of PPC calculations, the project team was ready to keep their commitments and improve the project performance.

Similarly, a comparison of the reasons for incomplete weekly assignments were analysed for each phase and further compared for the entire project duration. This is depicted in Figure 6.16. From the analysis, it is observed that equipment breakdown was the major reason for incomplete assignment for the 3 phases of 24-weeks recorded. It had a total frequency of 85 occurrences. This is because during any road construction project in Nigeria, plants and equipment are the main items used in carrying out the project. Hence, when equipment and plants breakdown or are unavailable, there is a chain effect on the project program and outcome.

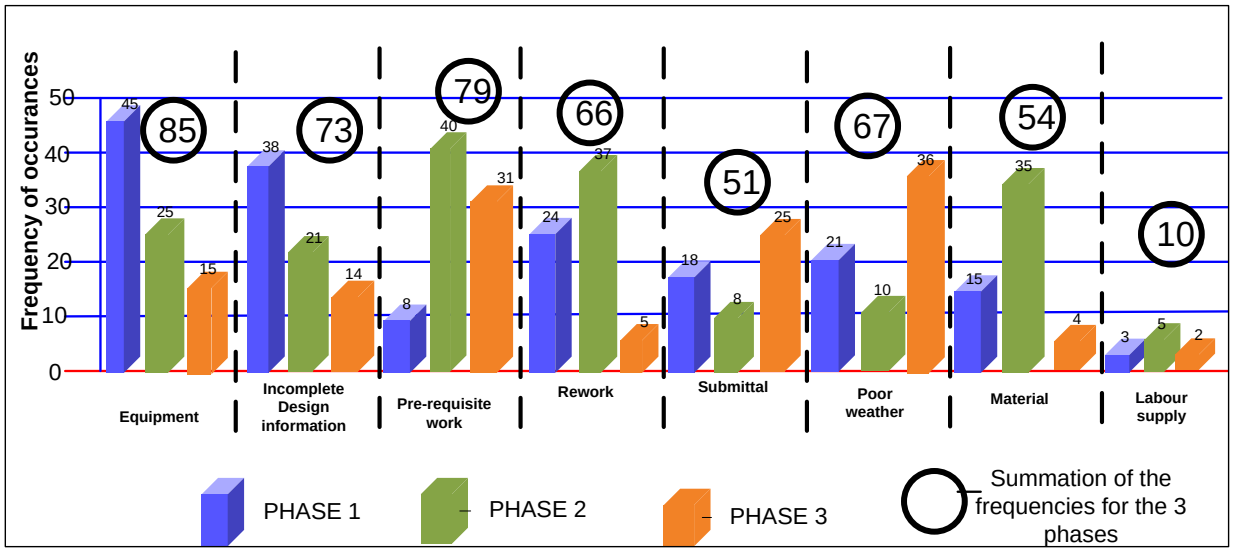


Figure 6.16 Comparison of Weekly PPC's for the three phases

In the same vein, a road construction project is linear in nature; hence it is mandatory that some tasks have to be completed before others start. For examples, asphalting will only commence after the road section to be asphalted has been primed, and priming will only take place and all earthworks has been completed. Similarly, the earthwork depends on clearing and setting out of the road. All of these indicate the importance of pre-requisite work and pre-requisite work was

observed to be the second most recurrent reason for incomplete assignments throughout the entire project implementation period, with a total frequency of 79.

Furthermore, incomplete design information was the third most frequent reason, with a frequency of 73. It was observed that three weeks into commencement of the project, the working drawings and specifications were not ready. The contractor had to wait for the consultants to furnish them with the specifications of the vertical and horizontal alignments. This however caused most of the planned assignments not to be completed.

The fourth was poor weather. This was a major reason for incomplete assignments during the third phase of the implementation. The poor weather was mainly excessive rainfalls resulting in flooding of the road sections, caused most of the planned work to be suspended. Most graded sections were scarified and re-graded which was counted as rework. Hence rework was recorded as the fifth most frequent reason for incomplete assignment throughout the entire implementation period.

Additionally, community disturbances caused material unavailability within the second phase of the 24 weeks of the full implementation period. This material unavailability reoccurred 54 times as reasons for incomplete assignments. While, submittals i.e. sending in late requests for materials and equipment resulted in the sixth most frequent reason for incomplete assignments and labour supply was the lowest reason for incomplete assignment; because equipment's were mainly relied upon to carry out majority of the tasks.

6.6.5. THE BRIDGE CONSTRUCTION

This project also entailed the construction of an 80m span bridge, with 11m wide deck and 1.3m raised walkway on both sides of the road. The bridge project was coordinated by a subcontractor who had expertise on bridge construction within Nigeria. The subcontractor was contacted by the

main contractor and the researcher on the need to implement LPS during the construction of the bridge. The subcontractor was however, adamant and refused to implement LPS or attend the introductory meeting of Lean construction and LPS.

On the other hand, the researcher was allowed to interview and observe site activities within the bridge construction. During the non-participant observation by the researcher, it was observed that the subcontractor started off with great enthusiasm by conducting the bytemetry surveys to determine the water levels and pile locations; piling of the piers and abutments; construction of formworks, reinforcement of the piers and abutments; concrete castings of the prepared formworks.

It was however discovered that most elements in the specifications for the superstructures were missing in the detailed design. This caused a huge delay to the project. This made the subcontractor wait on the designers to furnish him with the details missing in the design. However, it took the bridge consultant three months to provide the required information and by the time the design information was provided, the subcontractor had already demobilised from the site. It took the subcontractor another two weeks to mobilise a few of his staff back to the project and when the commenced work, it was observed that some of the reinforcement schedules in the piers had to be changed as the design had been slightly altered. This caused the subcontractor to abandon the project.

The researcher interviewed the project team of the subcontractor handling the bridge before the construction commenced. It was identified that prefabrication elements, which is widely known to reduce design and construction errors; speed up time of project delivery was not being used by the subcontractor. Conversely, all construction activities were done in-situ. Figure 6.5 and figure 6.6, (Page 135) shows images of the bridge under construction.

Furthermore, the interviews revealed that there was no communication plan between the subcontractor and the bridge consultant, causing miscommunication and late responses. Similarly hardly any meetings between the project stakeholders (consultants, contractors, subcontractors and suppliers) was recorded. This would have overcome envisaged problems.

On the contrary, the road construction aspect of the project was completed within the estimated cost and delivery time. This success in project delivery cost and time was attributed to the LPS implementation. LPS was reported to have helped increase motivation of the workers to complete the project; made the project team coordinate better and allow the team identify and resolve issues before they became problems at site.

6.6.6. THE SURVEY QUESTIONNAIRES

The survey questionnaires were administered to the entire project participants to evaluate the LPS implementation process. Each questionnaire was divided into four sections (A-D) with the first section getting an overview of the effects of the implementation. The second section dwelt on the barriers while the next sections focused on the critical success factors of LPS and the finally the fourth concentrated on the benefits gained from the LPS process.

The respondents to the question included the main contractor team, the consultants, the subcontractors and suppliers. Their responses were analysed using statistical analysis. Table 6.4 shows a breakdown of the respondents a percentage of their participation.

Table 6.4 Breakdown for the rate of questionnaire respondents for Case Study 2

Participants	**Number Distributed**	**Respondents**	**Percentage**
Contractor team	12	11	92%
Consultants	4	4	100%
Subcontractors	6	2	33%
Suppliers	3	2	67%
TOTAL	*25*	*19*	*76%*

SECTION A

This section focused on the overview of the implementation, with four different questions being asked on the: effectiveness of LPS; the fulfilment of the results; the usefulness of the WWP and PPC's; and the degree of difficulty in carrying of the implementation. Table 6.5 shows the details of the respondents.

From the responses, it was gathered that LPS was effective within the project and compared to previous projects, it was satisfactory. It was also identified that the weekly work plans and PPC are useful tools for improving productivity. Although, it was observed from the questionnaire, that the implementation process was not easy. It was the first time the project participants were participating in an LPS project.

Table 6.5 Overview of the implementation (Section A) Case Study 2

s/n	Reasons	weighting frequency (f)									
		1	**2**	**3**	**4**	**5**	$\sum f$	$\bar{x}$	**RII**	**RANK**	**%Rating**
1	*LPS was effective*	0	0	0	13	6	19	4.31	0.86	3rd	100%
2	*Results obtained were satisfactory*	0	0	0	4	15	19	4.79	0.95	2nd	100%
3	*WWP & PPC was useful*	0	0	0	2	17	19	4.89	0.98	1st	100%
4	*difficulty in carrying out the implementation*	5	10	3	1	0	19	2.00	0.40	4th	5%

Table 6.6 Barriers during the implementation (Section B) Case Study 2

s/n	Barriers	weighting frequency (f)									
		1	**2**	**3**	**4**	**5**	$\sum f$	$\bar{x}$	**RII**	**RANK**	**%Rating**
1	*Poor supervision & quality control*	0	2	4	12	1	19	3.63	0.73	5th	68%
2	*Fluctuations & variation*	0	4	8	6	1	19	3.21	0.64	6th	37%
3	*Subcontractors involvement*	0	2	5	9	3	19	3.68	0.74	4th	63%
4	*Resistance to change*	0	0	6	10	3	19	3.84	0.77	3rd	68%
5	*Cultural issues*	0	0	1	13	5	19	4.21	0.86	1st	95%
6	*Lengthy approval*	0	0	2	9	8	19	4.31	0.84	2nd	89%

Table 6.7 Critical success factors to the implementation (Section C) Case Study 2

s/n	Factors	weighting frequency (f)									
		1	**2**	**3**	**4**	**5**	$\sum f$	$\bar{x}$	**RII**	**RANK**	**%Rating**
1	*Training & empowering last planners*	0	0	0	15	4	19	4.21	0.84	3rd	100%
2	*Team work*	0	0	3	15	1	19	3.89	0.78	6th	84%
3	*Motivating people to make changes*	0	0	0	9	10	19	4.52	0.90	2nd	100%
4	*Appropriate human capital*	0	2	5	8	4	19	3.74	0.75	7th	63%
5	*Top management support*	0	0	0	8	11	19	4.58	0.92	1st	100%
6	*Managing resistance to change*	0	2	3	8	6	19	3.95	0.79	5th	74%
7	*Close relationship with suppliers*	0	0	1	16	2	19	4.05	0.81	4th	95%

Table 6.8 Benefits of the implementation (Section D) Case Study 2

s/n	Benefits	weighting frequency (f)									
		1	**2**	**3**	**4**	**5**	$\sum f$	$\bar{x}$	**RII**	**RANK**	**%Rating**
a	*Solve problems on time*	0	1	7	4	7	19	3.89	0.78	7th	57%
b	*Reduces bad news*	0	0	0	10	9	19	4.47	0.89	1st	100%
c	*Reducing load on management*	0	0	1	8	7	16	3.68	0.74	9th	95%
d	*Predictable & reliable work plan*	1	1	3	7	7	19	3.95	0.79	6th	74%
e	*Projects are safer, faster and within cost*	0	0	2	11	6	19	4.21	0.84	4th	90%
f	*Stabilises projects*	0	0	1	9	9	19	4.42	0.88	3rd	95%
g	*Improves logisitics*	1	1	3	9	5	19	3.84	0.77	8th	74%
h	*Improves predictions of labour*	1	2	3	9	4	19	3.68	0.74	9th	68%
i	Reduces risks	0	3	0	10	6	19	4.00	0.80	5th	84%
j	completes project on schedule	0	0	0	10	9	19	4.47	0.89	1st	100%

SECTION B

The question in this section centred on the barriers faced during the implementation. The questions were formatted using a 5-point likert scale for reach attribute attached to the question. The attributes were divided into six options identifying possible barriers to the LPS implementation. Table 6.6 and Figure 6.17 combined shows a holistic description of the responses, with figure 6.17 showing their views on a bar chart.

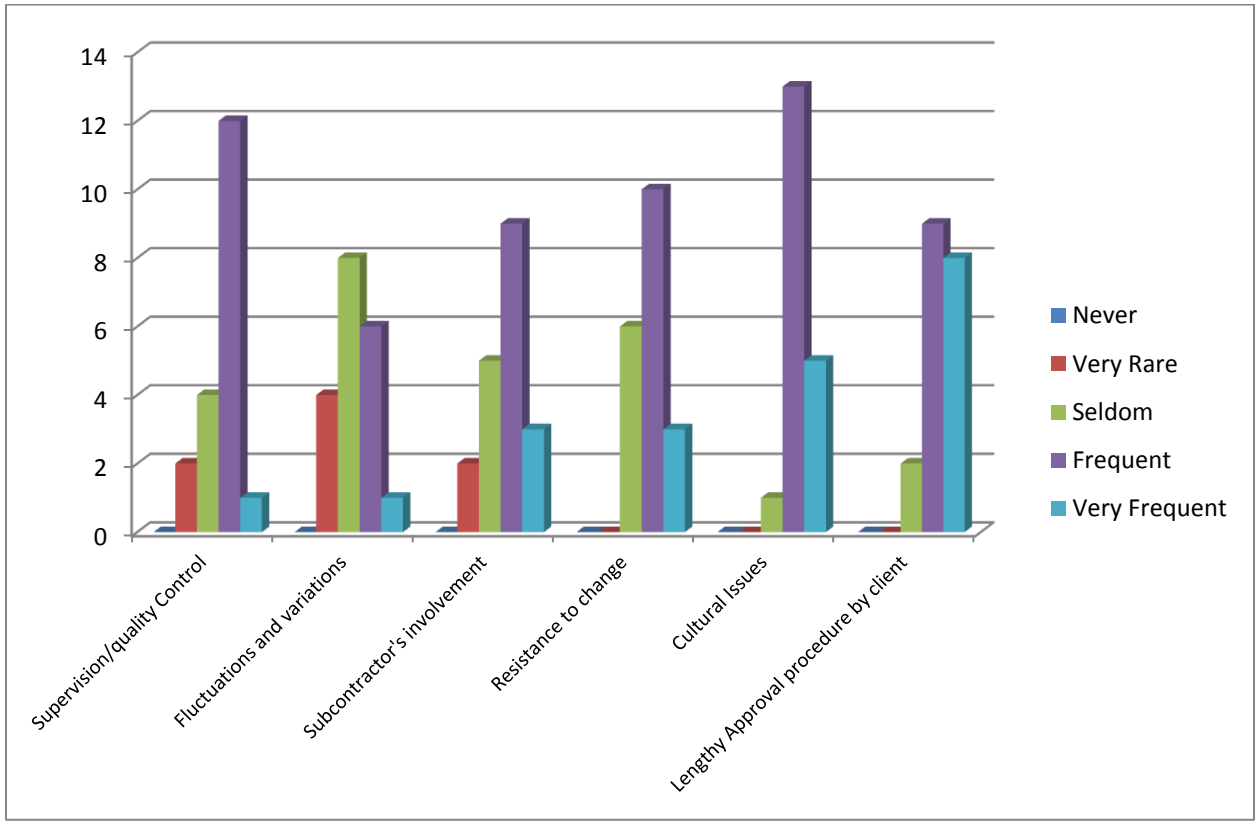


Figure 6.17 Barriers during the implementation of LPS on Case Study 2

The aim of this section was to obtain participant view of some of the possible barriers experienced during the implementation. From Table 6.6 and Figure 6.17, the cultural issues were widely seen by all the respondents as a possible barrier to the implementation. This was followed by 'lengthy approval procedure by clients'. In general, the response analysed within this section reveal that the all the respondents accepted that each of the 6 attributes were possible barriers.

These barriers were similar the usual barriers that faced during the implementation of LPS from the literature reviews.

SECTION C

This section dwelt on the critical success factors of implementing LPS. Similar to the section A and B, the questions were formatted using a 5-point likert scale. The attributes were possible success factors derived from the literature reviews and from the site observations during the implementation. Tables 6.7 and Figure 6.18 shows the views of the respondents.

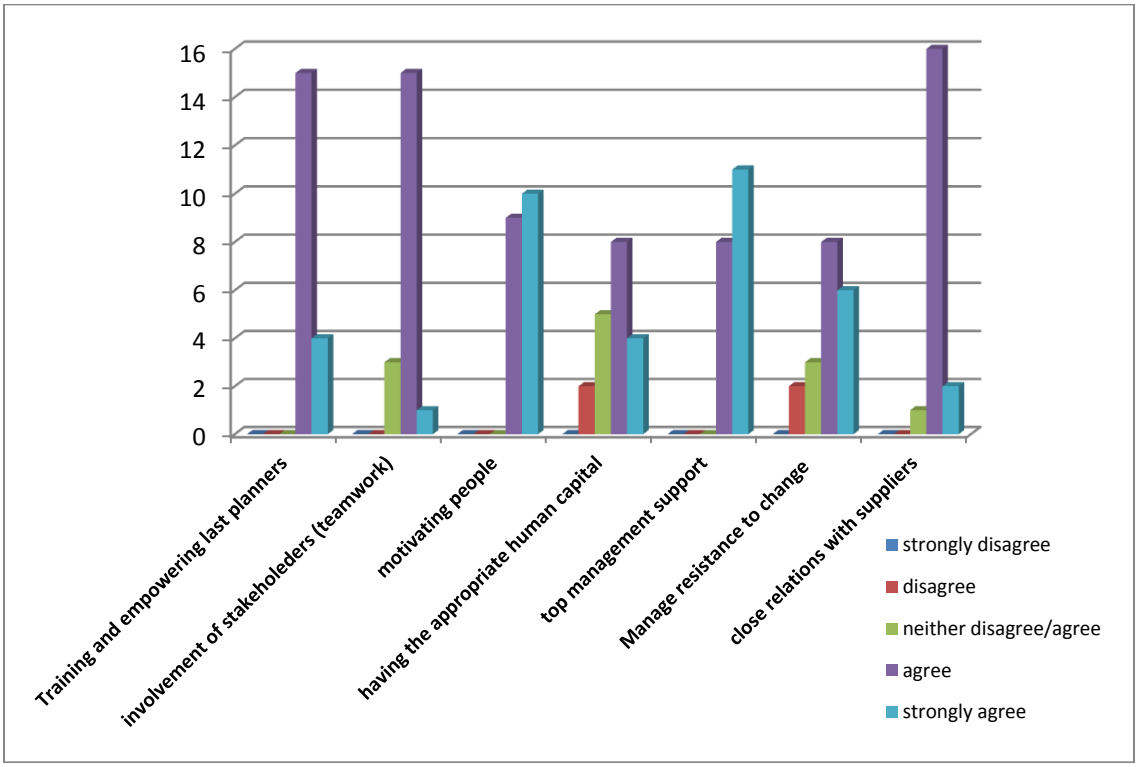


Figure 6.18 The Critical Success Factors to the implementation of LPS on Case Study 2

It is apparent from the responses gathered, that most of the participants were in agreement for most of critical success factors (CSF). Although it was also observed that two respondents disagreed that 'having the appropriate human capital' is a CSF, while another two also disagreed that 'managing resistance to change' is a CSF.

A summary of the CFS for this section is analysed in the discussion below. The analysis ranks the CSF in accordance to the highest agreement level by the respondents.

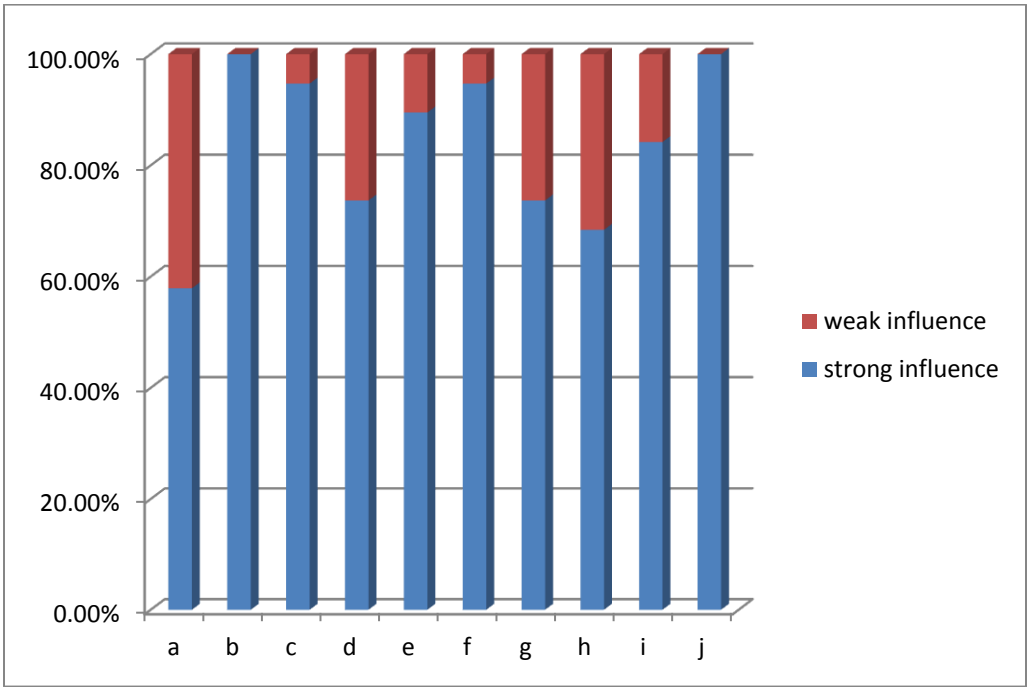
1. Top Management Support. The main contractor's management team supported the entire implementation process. This accounted for one of the main reasons for the successful implementation of LPS. This boosted the confidence of the project team and made them more committed in the implementation process, knowing that they had management support. Hence, of the 19 respondents 11 strongly agreed while the remaining 8 also agreed that this was a major CSF.
2. Motivating people to make changes. The project participants were willing to change and try out new processes, after they were motivated during the introductory workshops held before the start of the implementation. The researcher during the workshops discussed the benefits to be gained as recorded in the literature review. The researcher also motivated the team by encouraging them that understanding the entire process takes time but the little efforts of practicing the process brings understanding. This helped boost the confidence of the project team and hence the entire respondents agreed that this was a CSF, with 10 strongly agreeing while 9 indicated that they agreed.
3. Training and empowering Last planners. This was identified from the survey results as the third CSF of the implementation. All the respondents agreed that this was a CSF, with 4 of the 19 strongly agreeing and the remaining 15 indicated that they agreed. It was observed that if people were adequately trained and empowered LPS will be successfully implemented.
4. Close relations with suppliers. Within this project, it was observed that, having a close relationship with the suppliers and building trust amongst both parties helped in reducing

delays from some of the main suppliers. Of the 19 respondents only one was unsure if this was a CSF to the project, while the rest 18 agreed that having a close relationship with suppliers was a CSF to the implementation.

5. Involvement of all stakeholders (teamwork). Team work was a key factor to the successful implementation of LPS. It required the involvement and cooperation of the entire project stakeholders i.e. the contractors, consultants, clients, suppliers and the subcontractors. Although, from the analysis of the responses gathered, it was recorded that 3 respondents neither agreed nor disagreed this was CSF, while the remaining 16 agreed.
6. Managing resistance to change. Results from the survey revealed that 2 of the 19 respondents disagreed that 'managing resistance to change' was a CSF to the implementation. Another 3 were unsure and they neither agreed nor disagreed, while the remaining 14 agreed that if resistance to change is properly managed, it would be a CSF to LPS.
7. Having the appropriate human capital. Finally, having the appropriate human capital in terms of technical skills, expertise and experience should be well considered when implementing LPS. Selecting people well suited for any particular project would determine the rate of success of such a project. Hence having the right team could serve as a CSF. This was the view of 12 of the respondents who agreed that it was a CSF, while 5 out of the remaining 7 were unsure if this was a CSF, whereas the remaining 2 disagreed.

SECTION D

This section focused on the benefits of implementing LPS. Ten benefits were suggested as possible benefits of implementing LPS and respondents were expected to express their views in a 5-point likert scale, indicating there levels of agreement in terms of degree of influence each benefit had. Table 6.8 shows the responses gathered from this section, and the frequency of influence the perceived benefits had on the project.



a= Identifying & addressing potential problems before they become obstacles in the project
b= Reducing the incidence of bad news & to get what bad news there is early
c= Developing supervisory skills and reducing the load on management
d= Creating a more predictable & reliable production program
e= Delivering projects more safely, faster & at reduced cost
f= Stabilizes projects & support other lean actions
g= Improving construction logistics on projects
h= Improving predictions of labour required
i= Reduces the risk of catastrophic loss
j= Completes projects on schedule

Figure 6.19 Benefits of implementing LPS on Case Study 2

From Figure 6.19, the percentage of agreement is clearly shown for each of the attributes. It was observed that 100% of the respondents agreed that LPS reduces the incidence of bad news and

completes project on schedule. Similarly, 95% respondents agreed to the benefits that LPS develops supervisory skills, reducing the load on management, and that it stabilises projects and supports other lean actions.

Additionally, 89% of the respondents agreed that LPS delivers projects more safely, faster and at reduced cost. While 84% of the respondents agreed that LPS reduces risk of catastrophic loss. Furthermore, 74% of the respondents agreed that LPS creates a more predictable, reliable production program and that it improves construction logistics on projects.

Finally, 68% of the respondents surveyed agreed that LPS improves prediction of labour required to carry out tasks, while 58% agreed that LPS identifies and addresses potential problems before they become obstacles.

6.7. CHAPTER SUMMARY

This chapter described in considerable detail the process of implementing LPS in a road construction project in Nigeria. The chapter also analysed the findings from the survey questionnaire to assess participants' views of the process. On the whole, they agreed that LPS had a significant and positive impact on the whole project management by enhancing planning practice and improving site management. Unfortunately, while the road aspect of the project recorded successes, the bridge construction aspect had a lot of technical challenges and this led to the subcontractor handling the bridge to abandon the project.

7. Chapter Seven - Case Study 3 (HYDRO-POWER DAM)

7.1. INTRODUCTION

This chapter describes the third case study project; a multipurpose hydro power dam construction project. Here the researcher conducted an empirical study to understand the state of production plan reliability on the project. The researcher also studied the actual project management techniques utilised in the project in comparison with typical LPS projects. This dam project was intended to control and prevent the effects of a possible flood disaster in several coastal states in Nigeria due to the possibility of the rupture of Lake Nyos in Cameroun.

The chapter begins with the case history followed by the case description, in which details of the scope on work of the project is highlighted. Furthermore, the description of the research activities carried out on the project is discussed. Finally, the data gathered is analysed and the findings discussed.

7.2. CASE HISTORY

The project entailed the construction of the Kashimbilla multipurpose dam at the Kastina-Ala River, which is located between Kashimbilla and Gamovo towns in Takum Local Government Area of Taraba State. The dam is being constructed as a buffer against any imminent environmental disaster that would occur at the collapse of the structurally weak volcanic lake Nyos situated in the Bamenda Plateau in Cameroun, which is 300m above sea level.

It was perceived as sighted in (FMWR, 2013) that if this disaster should occur, six States within Nigeria will be completely submerged. Hence, the Federal Government of Nigeria embarked on this emergency project to avert any possible disaster at the eruption of the lake. Furthermore, the project also targeted to maximise the huge potentials in water resources; such as tourism, irrigation, hydropower generation and water supply systems.

7.3. CASE DESCRIPTION

The contract for this multipurpose dam was awarded to a multinational company with specialties and experience in dam construction. The company also had a tract record and reputation of completing projects on time, within budget and to the required specifications. Hence the Federal Government of Nigeria was confident that the company could handle the technicalities of the project, thus they awarded the contract at an approximate sum of £244,000,000.00 (N 61,000,000,000.00).

The scope of work to be executed by the contractor includes the following (FMWR 2013):

- The construction of the main buffer dam; which was made up quarry rocks extending in a gentle slope across the Kashimbilla River. The estimated length of the dam was 1.585 Km with a height of 35m above sea level.
- The construction of a reservoir capacity of 500 million cubic meters of water, a treatment plant; with capacity of 60,000 cum/day and a water distribution network to serve at least 400,000 persons per day.
- The construction of a hydroelectric power generation of 40MW hydro power capacity.
- The construction and development of irrigation networks of about 2000ha.
- Construction of access road of about 11km and
- The construction of an Aircraft landing strip.

The progress of work attained for the entire project is over 65% completed. With some items listed in the scope already 100% completed.

Figure 7.1 Picture Gallery of the Kashimbilla multipurpose buffer dam

7.4. RESEARCH ACTIVITIES AT THE PROJECT SITE

The research activities included: observations, interviews and questionnaire surveys.

7.4.1. OBSERVATIONS

Research activities within the project commenced with observations around the project site; this was carried out by monitoring how site activities were planned, scheduled and controlled. During this period, the researcher observed that the project participants worked collaboratively even

though the project was a very massive one. It was also observed that the project manager was very practical in his day to day running of the site. He got involved in every aspect of the project; he practically ensured site superintendents completed planned activities on time and in the right standard.

7.4.2. INTERVIEWS

After two weeks of observing site activities, the researcher interviewed some of the key project participants using a series of semi-structured interview questions. Each interview session lasted for about 40 minutes and the interview sessions were carried out with the project manager, project consultant, project engineer and site engineer.

The main thrust of the interview was to draw out important issues pertaining the way the dam project was organised that it turned out to be a highly successful project in Nigeria despite the complicated nature of the project. The interview was also formatted in such a way that the interviewees explained their understanding of the project management system adopted within the project. The semi-structured interview questions used are shown in Appendix 4.

Each of the interviewees provided the researcher with their own account of how planning and forecasting of labour and materials occurred within the project, this was basically based on their professional experience. The key findings are summarised below:

1. All the interviewees recognised and stated that within this project, the conventional project management system (primavera or critical path networks) was not being practiced. Although from the range of views expressed they were aware of the traditional project management practice and have also applied it in some other project in the past.
2. During the interviews they were all asked if they were familiar with Lean construction and its related tool. Only the project manager (PM) stated that he had previous

knowledge of Lean construction. He however, stated that he hasn't been on any Lean construction project but was looking forward to such a project.

3. Furthermore, the interviewees related how the PM was very dynamic and so involved in every aspect of the project. One of the interviewees labelled the project management approach as being a practical project management approach. This was basically because; the PM was too involved in the project.
4. Health, safety and welfare together with communication, team work and leadership were identified by all the respondents as important aspects of delivering successful projects.
5. The PM stated that he did not schedule tasks that were required to be done and push down to the work crew, expecting them to follow his orders and get it done, rather he was involved in every aspect of the task that he scheduled to be carried out, ensuring that team members carried it out in the right specifications.
6. The PM also stated in his interview that about four months was spent in the logistics planning for this project. Site services and utilities had to be planned for, to attend to temporary needs of the project without interruption.
7. Finally, the interviewees identified several factors that potentially posed as a challenge within the project, and they however identified possibilities to overcome some of them. Some of these challenges identified included: weather (regular and heavy rains), bureaucracy from the client and security threats from different militant groups to disrupt the project.

   Furthermore, in overcoming weather, two teams were deployed to work in shifts; day and night, so as to cover-up more work periods where the weather was fair. In the same vein, bureaucracy was overcome by raising regular certificates and valuations for payment,

though the project did not rely on the payments made to move forward. Consequently work continued at site even though payments were delayed due to bureaucracy.

Furthermore, in order to overcome the security threats, soldiers were deployed to the site and surrounding communities.

7.4.3. QUESTIONNAIRE SURVEYS

Questionnaire surveys were sent out to the project participants specifically site operatives. The questionnaire was designed to be 'respondent-friendly' so as to get the most out of the responses. The questionnaire was divided into three sections. The first section requested general personal information about the respondent, while the second and third section focused on details of current construction culture within the project in terms of attitudes, believes and actions, while identifying the current construction practice in place together with performance of the project in terms of the overall performance of the project.

For the questionnaire development, the questions were both closed ended and open ended, formatted using a 5-point likert scale. The sample of the questionnaire is found in appendix 5A.

The findings recorded here only deals with the second and third section of the questionnaire; focusing exclusives on the respondents perception on the performance of the project. Details of responses gathered from these sections are shown in Tables 7.1 and 7.2

Table 7.1 Overview of the performance of the project (Section 2) Case Study 3:

s/n	Factors	weighting frequency (f)									
		1	**2**	**3**	**4**	**5**	$\sum f$	$\bar{x}$	**RII**	**RANK**	**%Rating**
1	*Direct access to management*	0	0	0	10	20	30	4.67	0.93	2nd	100%
2	*Collaboration between site operatives*	0	0	0	18	12	30	4.40	0.88	3rd	100%
3	*Free communication*	0	0	0	9	21	30	4.70	0.94	1st	100%
4	*Effective H&S system*	0	3	6	19	2	30	3.67	0.73	7th	70%
5	*Creativity*	0	0	4	18	8	30	4.13	0.83	6th	87%
6	*Regular project management approaches*	0	0	2	18	10	30	4.27	0.85	5th	93%
7	*Recognise performance*	0	0	0	19	11	30	4.36	0.87	4th	100%
8	*Staff training & development*	1	11	7	7	4	30	3.07	0.61	8th	37%

Table 7.2 Perception of the project participant on the organisational structure (Section 3) Case Study 3

s/n	Reasons	weighting frequency (f)									
		1	**2**	**3**	**4**	**5**	$\sum f$	$\bar{x}$	**RII**	**RANK**	**%Rating**
1	*Innovation*	0	0	0	3	27	30	4.90	0.98	1st	100%
2	*Organisational commitment & care*	0	2	1	13	14	30	4.30	0.86	2nd	90%
3	*Wages*	2	8	3	10	7	30	3.33	0.67	3rd	57%
4	*Welfare facilities*	3	7	6	8	6	30	3.23	0.65	4th	47%

From Table 7.1, it was revealed from the responses recorded in this section (from the Q1) that Site operatives had access to the manager of the site. This demonstrated good leadership on the part of the management as they were approachable by site workers. In the same vein, the respondents of the Q2 revealed that site operatives worked collaboratively among themselves. This was an important workplace attitude, and it was linked to the communication among site operatives; consequently from the survey, it was observed that the respondents accepted that there was an open and free communication channel in place within the project site.

Q4 dwelt on the Health and safety systems in place for both site operatives and the general public. It was identified that 10% of the respondents disagreed to the effectiveness of Health and safety system in place, while another 20% neither agreed nor disagreed to this effectiveness, with the remaining 70% acknowledging health and safety was effective. Similarly, in Q8, 3% of the respondents strongly disagreed on staff training and development. Another 37% also disagreed, stating that there was no staff training and development programs in place, although 23% could neither agree nor disagree with the remaining 37% stating that staff trainings and development were in place. However, probing further on the characteristics of respondents that indicated that there was staff training in place as against those that claimed there was none in place, it was revealed that the junior or lower level operatives on site indicated that there was none in place because they did not benefit from the senior staff training programs. On the other hand the senior operatives within the site indicated that they benefited from training and other staff development programs.

For Q5, 13% neither agreed nor disagreed that the project organisation encouraged site operatives to be creative and try out new thing, while the remaining respondents agreed that the project organisation encouraged creativity. Similarly, in Q6, 7% neither agreed nor disagreed

that the site managers had a constant track of the performance of the project, while the remaining respondents acknowledged that site mangers were constantly tracking the performance of the project at site.

Finally, the Q7 focused on the respondent's opinion about the involvement of the site managers in recognising the performance of site operatives. Here it was revealed that the entire respondent's acknowledged that the site mangers recognised the different performance of the site workers.

Furthermore, the other section of the questionnaire which is illustrated in Table 7.2 deals with the ratings of the project management system in place within the project. This project management is in terms of innovation, commitment and concern to workforce including staff welfare etc. the questions were formatted using a 5 point likert scale to measure the level of respondents satisfaction to the different questions raised in this section.

From Q1 in this section, it was observed that on the level of innovation within the project, here all the respondents were satisfied, with 10% indicating that they were very satisfied while the remaining 90% indicated that were satisfied on the level of innovation within the project in comparison with other projects they have participated in.

The response from Q2 showed that 6% of the respondents were not satisfied with the level of organisational commitment, care and concern displayed on the site. Similarly, in Q3, 43% of the respondents indicated that they were not satisfied with the wages they received on site. While in the Q4 60% stated that they were not satisfied with the welfare facilities in place at the site.

7.5. SYNTHESIS OF THE DATA OBTAINED

The synthesis of the data obtained from both the interview and questionnaire served as the triangulation of the data. It looked at the phenomenon using multiple sources of data collection

techniques; moreover it has the potential of overcoming bias and sterility of a single method. Hence three methods of data collect were used; they are literature reviews – to understand the characteristics and benefits of LPS; observations, interviews and questionnaires – to draw out important similarities pertaining the way the dam project was organised in relation to the benefits of LPS.

From literature reviews (Ballard, 2000; Mossman, 2009 and Mossman, 2012) it was observed that LPS enables the collaborative management of the entire network of communications and relationships within a project, which enables the effective co-ordination of project plans. It offers a realistic way to collaboratively manage projects by ensuring that issues are identified and resolved early before they become problems at project site. LPS is reported to increase work flow and ensure projects are completed on time, while serving as a vital link between logistics team and building assemble teams. It is useful in creating major improvements in program safety, inevitability, efficiency and profitability.

Similarly, the finding from the survey revealed that there was extensive cooperation between different project participants with high level coordination of the site activities. It was also revealed that there was an open and free communication channel in place, and workers were motivated, respected and satisfied with the level of leadership exhibited within the project. In addition, a high level commitment from production units was recorded and this resulted in predictable and reliable production program.

These findings matched the benefits of implementing LPS in projects as recorded in the literature reviews. Although it was recorded from the interview that LPS was not being practiced however it was observed that the project management approach used within the project was similar to the LPS approach.

A comparison of the dam project with an LPS project is shown below in Tables 7.3. The table compares different LPS themes as can be found in any project that fully adopts LPS; with the outcomes of the dam project.

Table 7.3 Comparison of LPS projects and the dam project

s/n	Themes	LPS projects from literature reviews	Dam project (Case study 3)
1.	Planning	When LPS is used within a project, uncertainties are reduced by systematically organising the project on a step by step basis, using a pull system to meet customer's requirement of time, cost and quality. (Arbulu and Soto, 2006; Kim *et al.* 2007; Kim and Jang 2005; Fiallo and Revelo 2002).	Good planning initiatives were in place as the findings of the interview revealed that the PM was systematic and thorough in his planning. Similarly, the interviews revealed that the PM scheduled each task based on a pull system rather than a push system.
2.	Control	This entails making sure that the work planned to be executed conform to the original plan. (Olano *et al*. 2009; Sterzi *et al*. 2007; Arbulu and Soto 2006; Kim *et al*. 2007).	From the interview findings, it was revealed that the PM was so involved in every aspect of the project, ensuring that the project conformed to plan.
3.	Logistics	LPS improves logistics by making	The PM stated in his interview that close to four months was spent in

		projects more predictable and by reducing the cumbersome processes required to carry out the construction. LPS ensures that there is flow of information, plant and equipment, materials and people. (Simonsson and Emborg 2007; Ballard *et al.* 2009).	the logistics planning for this project. A lot of time was spent in identifying and preparing the temporary site office, temporary access for movement and flow of material, plant, equipment and people.
4.	Collaboration	Collaboration is built when team members create and agree on the production sequence, collaboratively agree on the production tasks for the next day or week and when teams collaboratively monitor production to keep activities on track. (Hamzeh *et al.* 2009; Kim *et al* 2007; Kim and Jang 2005).	From the initial site observations, it was observed that the project participants worked collaboratively. To confirm this, all the respondents to the questionnaire survey affirmed that there was collaboration amongst all the site operatives.
5.	Learning	In LPS projects, learning occur so that project participants can measure and continually improve both planning and production processes. Similarly, LPS investigates the root causes of failures so as to gain insight on the patterns of failures.	The survey questions revealed that site operatives were encouraged to try out new things so they could learn new skills. In addition to this, the organisation provided for staff training and development. Learning also occurred when the

		(AlSehaimi *et al.* 2009; Ballard *et al.* 2007)	site managers tracked the performance of the project, this gave them an opportunity to learn from the mistakes that occurred.
6.	Relationships	LPS manages construction flow by building relationships and securing promises that enable the delivery of projects. These relationships establish lines of communication, develops trust and commitments. (AlSehaimi *et al.* 2009; Ballard *et al.* 2007; Kim *et al* 2007; Kim and Jang 2005)	Site operatives co-operated amongst themselves. The surveys revealed that there was as open and free communication channel amongst site operatives.

7.6. MAJOR DIFFERENCE BETWEEN A TYPICAL LPS PROJECT AND THE CASE STUDY

The major difference between typical LPS projects and this case study was in terms of leadership. The LPS tool on its own lacks details of leader however, Lean Leadership as a lean construction tool was exhibited within this project. This was illustrated in the relationship between the project manager and the project participants. LPS deals more on collaborative planning rather than leadership.

Nevertheless, the main features of LPS that promotes learning and continuous improvement was also lacking within this case study; Percentage of Plans Completed (PPC). Within LPS PPC is calculated on a weekly basis to identify the weekly outcome of planned work accomplished as

against the total planned activities. Porwal (2010) identified that PPC helps to measure the reliability of production planning and that of workflow. PPC analysis explains reasons why planned work was not done. The LPS feature was obviously lacking within this project.

7.7. SUMMARY OF FINDINGS

The findings from this case study revealed that there was extensive cooperation between different project participants with high level coordination of the site activities. It was also revealed that there was an open and free communication channel in place, and workers were motivated, respected and satisfied with the level of leadership exhibited within the project. In addition, a high level commitment from production units was recorded and this resulted in predictable and reliable production program.

In comparison with the Last Planner Systems, there was a huge similarity in the way the project was coordinated which resulted in similar outcomes. For instance, instead of the project manager to operate under the illusion that a complete master schedule has given a control over the projects, rather the project manager closely monitored the quality of the entire process together with the effectiveness of the planning system through the results that are recorded on a week-to-week basis. This offered the opportunity for the project manager to offer assistance to those project engineers and site superintendent whose planning reliability was low or not improving. These thus resulted in improved construction logistics, collaboration, transparency and trust, reliability of scheduling and delivery of value while, consuming the fewest resources. Which is similar to the outcomes recorded in LPS projects.

8. Chapter Eight - FRAMEWORK DEVELOPMENT

8.1. OVERVIEW

This chapter presents a framework for the successful implementation of LPS in Nigeria. The chapter commences by summarising the three case studies reported in this research and draws out the challenges of implementing LPS in Nigeria. It further reviews the results of the case studies with the overall aim of identifying the challenges of implementing LPS in Nigeria. The research was performed in an "action research" environment where empirical data was gathered, analysed and evaluated and a framework formulated for the successful implementation of Last Planner System in Nigeria.

Last Planner System is a Lean Construction solution (Ballard and Howell, 2004), and Lean thinking requires employees to change the way they view and execute their work (Salem and Solomon, 2006). Changing the cultural status-quo of a traditional system can not only be seen as cumbersome, but even threatening to people who have operated relatively successfully for years within the current system. Hence the novelty of this research is the implementation of LPS in an environment culturally characterised by fragmentation, antagonism, mistrust, poor communication, short-term mentality, lack of accountability and blame-culture; these attributes are in turn associated with project outcomes like poor quality work, cost and time overruns.

The proposed framework identified the different implementation hurdles from literature reviews and measured them while carrying out the LPS implementations in the case studies presented in this research. These hurdles include the supervision/quality control, fluctuation and variations, subcontractor involvement, resistance to change, cultural issues, lengthy approvals (Ojo *et al.*, 2014; Obuunwo *et al.,* 2013; Ahiakwo *et al.,* 2012; Olusegun and Michael, 2011; Oke and Ogunsemi, 2011; Aina and Wahab, 2011; Windapo and Martins, 2010; Oke and Ogunsemi,

2011). Consequently, eliminating theses huddles would aid the successful implementation of LPS in Nigeria hence bringing about positive change to the industry.

8.2. SUMMARY OF THE CASES

From the three case study projects examined, it was observed that the LPS promoted collaborative planning and advocated for learning from failures, which is vital for continuous improvement, thus making projects more predictable, minimising buffers, reducing uncertainties, creating reliable work plans, decreasing workflow variability and improving collaborative planning etc.

For the first case study project, which entailed the construction of four prototype student hostel buildings by four different indigenous contractors, and each of the contractors had the same design and scope for the building. However, out of the four contractors constructing the projects, it was observed that the fourth contractor produced substantial results in terms of time, cost and quality performances this was basically because the contractor implemented LPS which resulted in a better allocation of resources; an organised flow and access of materials. This implementation however experienced some barriers. These barriers were identified from questionnaire survey conducted which was then ranked by the project participants. The result is presented in Table 8.1

Table 8.1 Results from Case Study 1 on barriers to the LPS implementation

S/N	BARRIERS TO IMPLEMENTING LPS	RATING IN TERMS OF RESPONDENTS
1.	Resistance to change	97%
2.	Cultural issues	82%
3.	Subcontractors involvement	65%
4.	Fluctuations & variations	65%
5.	Lengthy approval	59%
6.	Poor supervision & quality	38%

Similarly, from the second case study project, this entailed the construction of a 4 Kilometre road and the construction of an 80 meter bridge across river Ebeku to link up with an existing road. It was recorded that the LPS implemented within the project reduced the incidence of bad news and completed the project on schedule. It was also reported that it reduced the load of trying to resolve issues on the management; rather it stabilised the project, delivering the project safely, faster and at reduced cost. Results from the case study also revealed that LPS within this project created a more predictable, reliable production program and improved the site logistics. However, some barriers were identified from questionnaire surveys sent out to participants; these barriers are tabulated and rated in Table 8.2

Table 8.2 Results from Case Study 2 on barriers to the LPS implementation

S/N	BARRIERS TO IMPLEMENTING LPS	RATING IN TERMS OF RESPONDENTS
1.	Cultural issues	95%
2.	Lengthy approval	89%
3.	Resistance to change	68%
4.	Poor supervision & quality	68%
5.	Subcontractors involvement	63%
6.	Fluctuations & variations	37%

Finally, from the third case study which entailed the construction of a multipurpose hydro power buffer dam project. Here the researcher observed how site activities were planned, controlled and coordinated, a comparison was established between the outcomes from the project and the outcomes of typical LPS projects. It was revealed from the observation, interviews and surveys that there was a huge similarity in the way the project was coordinated, managed and supervised. This resulted in improving collaboration, transparency and trust, reliability of production plans and the consumption of few resources within the projects.

8.3. FRAMEWORK DEVELOPMENT

Form the LPS implementation of case study 1 and 2, the percentages of the barriers that are recorded and the average of this percentage is calculated and tabulated in Table 8.3

Table 8.3 Average rating of barriers to the LPS implementation from Case Study 1 & 2

S/N	BARRIERS TO IMPLEMENTING LPS	RATING FOR CASE 1	RATING FOR CASE 2	AVERAGE
1.	Cultural issues	82%	95%	**88%**
2.	Resistance to change	97%	68%	**82%**
3.	Lengthy approval	59%	89%	**74%**
4.	Subcontractor's involvement	65%	63%	**64%**
5.	Poor Supervision & quality	38%	68%	**53%**
6.	Fluctuations & variations	65%	37%	**51%**

From the averages in Table 8.3, it is observed that 'cultural issues' and 'resistance to change' are identified as the major barriers to the LPS implementation in this research; this is followed by the barrier of 'lengthy approval'. Other barriers include 'subcontractor's involvement' and 'supervision/quality issues'. While the least barrier identified from both cases was 'fluctuation and variation'.

Consequently, a framework is proposed to overcome these barriers when applying LPS on similar projects in construction environment similar to that of Nigeria. The framework draws on experience from previous implementations and research in Lean (Ballard and Kim, 2007; Ballard *et al.,* 2007; Hamzeh, 2009). It offers a useful guideline for practitioners in Nigeria seeking to implement the Last Planner Systems. The framework highlights all the relevant elements that are necessary to considered before implementing LPS in an environment culturally characterised by fragmentation, antagonism, mistrust, poor communication, short-term mentality, lack of accountability and blame-culture.

Furthermore, it is important to note that LPS could be a relatively lengthy process requiring strong commitment from everyone involved in the process. This framework proposes a strategy for managing LPS in project circumstances and conditions in Nigeria (and countries where there are similar construction challenges as highlighted above). Additionally, it is important to note that the framework is not to be considered a pick-and-choose toolbox; it is also not to be seen as a rigid step-by-step model. Rather it offers guidelines on how to implement LPS while minimising the six major barriers identified from case study 1 and 2.

The pathway to mitigate these barriers identified is illustrated in the framework implementation guide. The main features of the framework are: input themes, contextual themes and output themes. This is illustrated in Figure 8.1

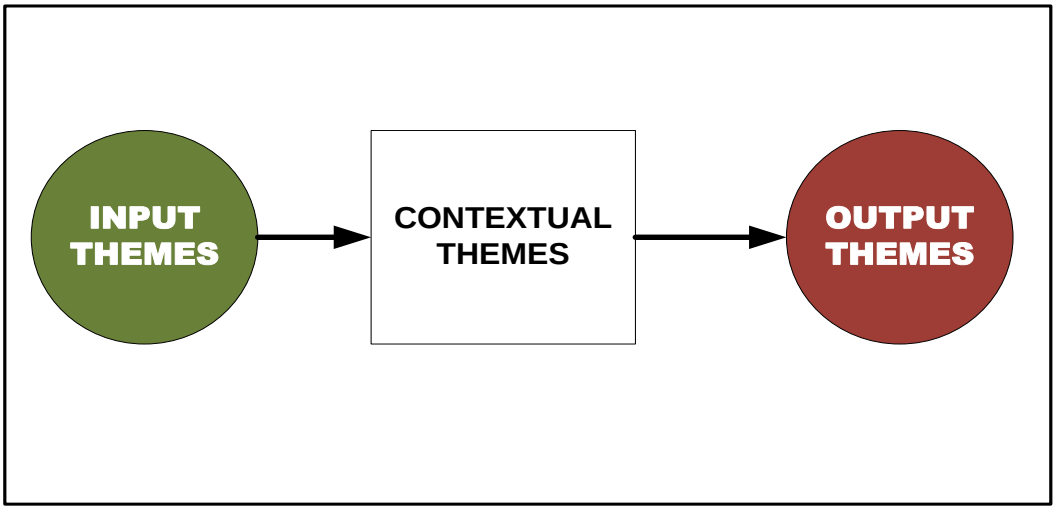


Figure 8.1 Main features of the framework

1. **The input themes:** these refer to the activities and processes that need to be put in place for the drivers in the contextual theme to function. These input themes include all detailed activities, requirements and preconditions that make up the each contextual theme. For each contextual theme, there are corresponding input themes. Figure 8.2 illustrates in details how the input themes operate within the framework.

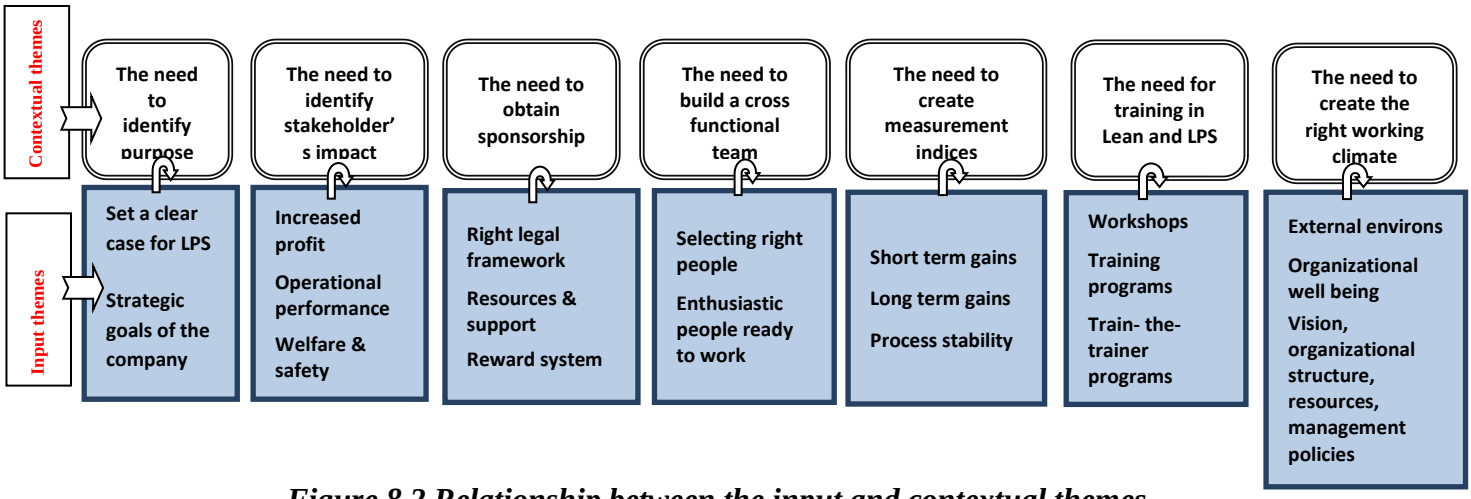


Figure 8.2 Relationship between the input and contextual themes

2. The contextual theme: these refer to main drivers of the framework. They are framed from the input activities and they form the key elements of the framework. Their basic function is to mitigate the barriers of implementing the LPS. The main drivers include: the need to identify purpose, the need to identify stakeholders impact, the need to obtain Sponsorship, the need to build a cross functional team, the need to create measurement indices, the need for training on Lean techniques and LPS, and the need to create a right working climate

3. The output theme: these themes are primarily the barriers the main drivers intend to mitigate. They include: cultural issues, resistance to change, lengthy approval, subcontractor's involvement, poor supervision and quality control, fluctuations and variations.

The framework emphasises what must be done to manage the change process itself. While it uses the following themes to demonstrate the interrelatedness and dependencies of preconditions to be met for the successful implementation of LPS in the Nigerian construction industry.

The main steps or drivers guiding the framework include the following:

1. The need to identify purpose
2. The need to identify stakeholders impact
3. The need to obtain Sponsorship
4. The need to build a cross functional team
5. The need to create measurement indices
6. The need for training on Lean techniques and LPS
7. The need to create a right working climate

1. **The need to identify purpose:** The need to identify purpose can be described as one of the first step to the successful implementation of any change initiative (Kotter, 2006). This includes the Last Planner System within any organisation in Nigeria especially with the level of awareness of LPS in the Nigerian construction industry. It is necessary to first clearly state the need for LPS, since the cultural attitude of most of the construction organisation requires the purpose of implementing LPS within their organisation. Identifying purpose involves clearly articulating the purpose for implementing the LPS within the project (Hamzeh, 2009). For this reason 'identifying purpose' makes a clear case for the implementation of LPS and when put forward, it should be linked to the strategic goal of the organisation.

   The aim is to resolve challenges of lack of information and communication between the organisation and the project participants. It also sets out the need for the improvement proposed by LPS process and creates the zeal for the implementation. The need to identify purpose solves the barriers of lengthy approvals which usually are as a result of poor top management commitment and unrealistic expectations (Hamzeh, 2009). For

example if a clear case for LPS is set, there will be zeal and commitment from the top management which will eliminate bureaucracy and lengthy approval processes. Similarly, the barrier of poor supervision and quality control, and cultural issues will be eliminated or subdued if the purpose of LPS is identified.

2. **The need to identify Stake holder's impact:** The need to identify Stake holder's impact is seen as a second step of the proposed implementation framework. 'Stake holder' here refers to board members, organisation staff, suppliers, the society/community and the end users (Obunwo *et al.,* 2013). For the board, the impact includes increased profitability and improved operational performance. While for the staff of the organisation, the impact should be related to satisfaction of welfare and working conditions, less stress and better safety. For the suppliers, the impact is related to high profitability, cash flows and continuity of work. The society/community and end users, the impact includes better use of resources, less waste, more effective constructed assets for less and improved environmental performances. This theme mitigates LPS implementation barriers of: subcontractor's involvement, resistance to change, and cultural issues.

3. **The need to obtain Sponsorship:** This involved establishing the right legal framework for the development of LPS within the business and its suppliers (Hamzeh, 2009). Sponsors provide the required resources and support that could facilitate the implementation of LPS to deliver the required value. However, the introduction of a reward system could motivate project participants to take the LPS implementation process more seriously (Lindner, 1998; Lin, 2007). Consequently, the need to obtain

sponsorship mitigates the barriers of: (i) resistance to change, by creating the right financial commitments that would foster management support. (ii) lengthy approval; this barrier is usually as a result of budgetary limitations and lack of legal enforcement, however obtaining sponsorship creates the right legal framework that ensures fluidity of funds. It also endorses top management commitment given that they sponsor the implementation (Hamzeh, 2009).

4. **The need to build a cross-functional team:** Here attention should be given to building the right team by selecting people who are suited to coordinate the project and who are eager to be part of the project (Hamzeh, 2009). Similarly, Howell (2002) pointed out that 'building a cross-functional team' influences coordination among project participants, making the project participants enthusiastic and ready to work. Hence, this theme 'building a cross-functional' mitigates the barriers of poor supervision and quality control, resistance to change, and sub-contractors involvement while it encourages team work, and mutual respect among project participants.

5. **The need to create measurement indices:** This theme stipulates how LPS should be implemented and it entails measuring improvements made in terms of people; leadership and teams; processes and products; tools and techniques; outcomes and their benefits by focusing on the short term gains while paying attention on long term benefits (Aoieong *et al*, 2002; Howell, 2002). This is achieved after obvious problems have been identified and fixed. Creating measurement indices in the form of milestones to ensure the stability of the process; and hence improves supervision and quality control (Terry and Smith,

2011). Consequently, barriers such as ‘lengthy approvals’, ‘fluctuations and variations’, and ‘resistance to change’ are reduced.

6. **The need for detailed training on Lean and LPS:** Training involves organising workshops and training programs for the project team on the basic principles of Lean Construction and the Last Planner System (LPS) (Paton *et al*, 2008; Johansen and Porter, 2003). Othman, (2011) identified that detailed training on LPS can be selective, focusing only on the actual planners and other participants involved in the implementation process. Additionally, training is a continuous process that even involves organising a train-the-trainer-program, where trainers of LPS are trained for the wider application of the LPS (Hamzeh, 2009). Training minimises most of the barriers to the successful implementation of any change initiative (Paton *et al.*, 2008). When people gain knowledge of the change process they become inclined to participate in the process. Hence training eliminates resistance to change and cultural issues. Although resistance to change and cultural issues were the major barriers identified from the survey of case study 1 and 2, they can also be easily tackled by adequate training and enlightenment on the principles of Lean and the Last Planner System.

7. **The need to create a right working climate:** Creating a working climate entails managing the external environment in conjunction with the organisational well-being (Lindhard and Wandahl, 2013). This is achieved by imbibing the mission and vision of the company, to the project and the project participants. This also entails aligning the organisational structure, the available resources and technology, and the management

policies and procedures to promote the implementation process. These encourage challenge and involvement, trust and openness, playfulness and humour, freedom and risk taking among the project team selected (Terry and Smith, 2011). Thus eliminating barriers like cultural issues, resistance to change, lengthy approvals, subcontractor's involvement, and fluctuations and variations.

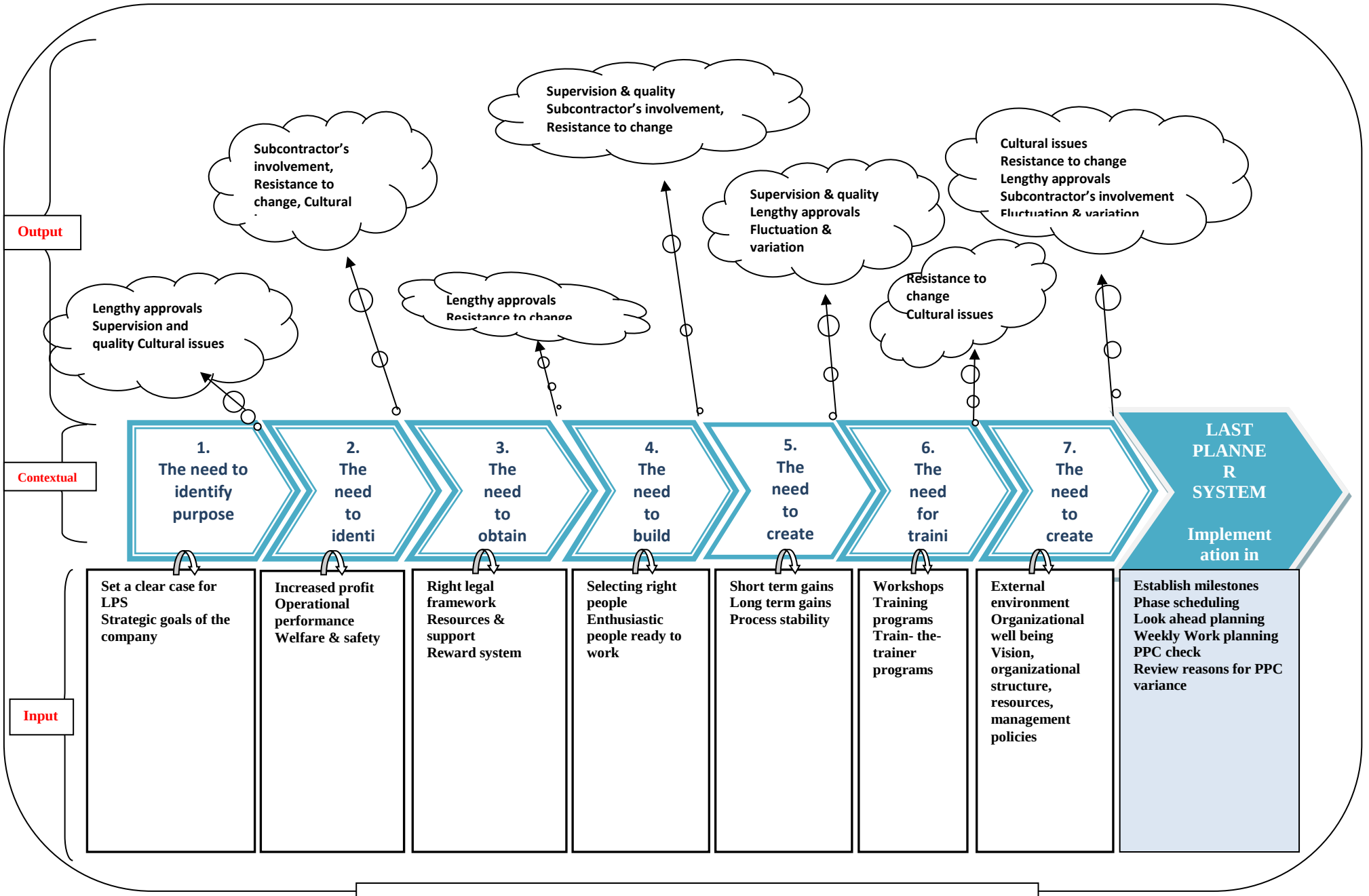


Figure 8.3 Proposed Last Planner implementation framework

8.4. EVALUATION OF THE LAST PLANNER IMPLEMENTATION FRAMEWORK

Having developed a framework, there was a need to test its utility before it can be more widely disseminated. The aim of this evaluation process is to determine whether the barriers and mitigation measures developed from the case studies and literature used for developing the framework are sound and sufficient. Evaluation is vital because it reveals the potential objectivity and reliability of any research (Golafshani, 2003). Evaluation is a key part of a framework development process which increases confidence in the framework while making it more valuable (Kennedy *et al.,* 2005).

Frees, (1996) describes the validation of a framework as the process of assessing and confirming if the proposed framework is appropriate to do what it sets out to achieve. Thus the evaluation of this framework intends to help ensure that the research has actually identified key barriers affecting the implementation of LPS in Nigeria and has sought to assess the extent to which the framework endeavours to mitigate these barriers. Hence a focus group discussion was utilised to carry out the evaluation process.

8.5. FOCUS GROUP

A focus group is defined as a group of interacting individuals, involved in a development intervention, having some common interest or characteristics, brought together by a moderator, who uses the group and its interaction as a way to gain information concerning peoples opinion and expectations about a specific issue (Marczak and Sewell, 2010). Similarly, Wilkinson, (2004) described a focus group as a way of collecting qualitative data, which essentially involves engaging a small number of people in an informal group discussion 'focused' around a particular topic or set of issues.

Focus groups are frequently used to evaluate a programme, a framework or an initiative particularly for fields with beneficiaries and intermediary stakeholders, where people's attitudes and opinions about an issue are discussed (Marczak and Sewell, 2010). In a nutshell, it is set up to get information concerning the people's opinions, behaviours, or to explain their expectations about a new programme, framework or initiative (Wilkinson, 1998). They are often used to gather data that are relatively broad, open ended and qualitative in nature (Krueger, 2000).

8.5.1. THE APPLICATION OF FOCUS GROUP

Morgan, (1988) and Krueger, (1988) identified the different scenarios where and when focus groups can be used. It was identified by these authors that Focus Group can be used; when considering the introduction of a new programme, framework or initiative; to help evaluate the impact of an existing programme or initiative; when asking questions that cannot easily be answered in a questionnaire or to supplement information already gathered; for programme improvement and organisational development.

However, for this research, focus group is used to evaluate the proposed LPS implementation framework developed from this research. The focus group is used to assess the robustness of the themes used in the development of the framework and also the draw out other barriers and mitigations in implementing LPS in Nigeria that probably was not captured during the framework development. Figure 8.4 below illustrates the role of the focus group for evaluating the proposed LPS implementation framework.

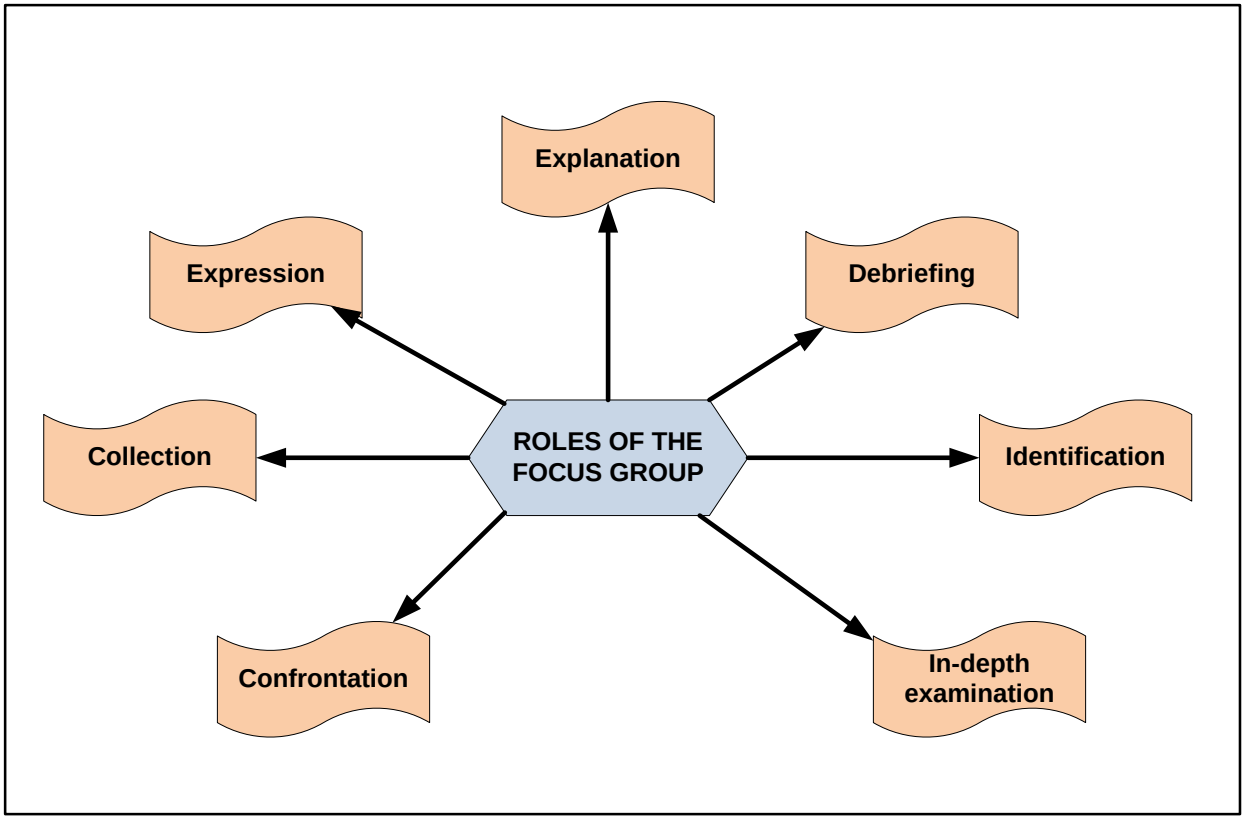


Figure 8.4 The Role of Focus Group in Evaluating the proposed LPS Framework (Wilkinson, 1998)

8.5.2. THE ADVANTAGES AND DISADVANTAGES OF USING A FOCUS GROUP

Focus Group involves looking at different views of stakeholders selected for a group discussion on a particular subject matter which usually yields multiple benefits (Butler, 1996). An example of the benefits is that focus groups are economical, fast, and efficient when used for obtaining data from multiple participants or stakeholders (Krueger and Casey, 2000). Another advantage of focus groups is that the environment, is socially oriented and it takes advantage of the fact that people naturally interact and are influenced by others (Krueger, 2000), and the sense of belonging to a group can increase the participants' sense of cohesiveness (Peters, 1993) and help them to feel safe to share information (Vaughn *et al*, 1996). It generally requires less preparation and is comparatively easy to conduct (Krueger, 2000).

Furthermore, the interactions that occur among the participants usually yields important information/data (Morgan, 1988), and can create the possibility for more spontaneous responses and is very flexible; can be used with wide range of topics, individuals, and settings (Butler, 1996), Furthermore, it provides a setting where the participants can discuss personal problems and provide possible solutions (Duggleby, 2005).

On the contrary there are some disadvantages of using focus groups; an example is that they can sometimes present a logistical challenge and they require a skilled facilitator (Krueger, 2000). In addition, Marczak and Sewell, (2010) identified that in Focus Group sessions the participants shape the discussion; therefore you may have little control over data collection and the sometimes may reflect the minority view. The next section therefore describes the focus group investigation process and the conclusions drawn from the findings of the investigation.

8.5.3. CONDUCTING THE FOCUS GROUP INVESTIGATION

An invitation to participate in the focus group evaluation process was sent to 12 construction professionals experienced in major construction projects in Nigeria. A total of 9 participants accepted the invitation. However, only 8 participants turned up for the focus group discussion although the 9th participant sent his apologies. Out of the 8 participants, 3 were also involved in the case studies reported in this research while the remaining 5 were senior construction professionals engaged in different construction projects similar to the case study projects recorded. The breakdowns of the characteristics of the participants are given below.

Table 8.4 Characteristics of the focus group participants

Codes for each participant	Current position	Industry experience
E1	Project manager	Multi storey hotel construction, real estate construction, highway and bridge construction.
E2	Construction manager	Commercial and industrial construction, road and bridge construction, experienced in budget analysis and resource allocation. Participated in case study 2
E3	Site Engineer	Interfaces with all teams with each project. Takes project from initiation through completion. QA/QC expert. Building and real estate contractor.
E4	Quantity Surveyor Consultant	Oil and gas, infrastructure, hydro power dam construction, earthworks, hotel and commercial building construction and office building quantity surveying, estimator and cost controller
E5	Project Engineer	Quality control, budget management, program and project management, on-site task scheduling, commercial and industrial construction, retaining wall, ware house road and bridge construction
E6	Civil Engineer	Commercial and industrial refurbishment, developing project program and site duties
E7	Quantity surveyor	Estimator, cost control for commercial and residential construction projects. Participated in case study 1
E8	Trainee Engineer	Coordinated construction activities at site, building and road construction. Participated in case study 2

The purpose of selecting this range of professionals was to determine diverging points of view on the proposed LPS implementation framework and to further determine its effectiveness when applied in the Nigerian Construction environment.

The focus group was held on Saturday 7th December, 2013 at 11am. Consent letters were given to each participant and the confidentiality of the data obtained was also explained. Thereafter, the

moderator commenced by stating the aim and goal of the focus group evaluation which is to evaluate the practicality of the proposed LPS implementation framework developed from this research and to also assess the potency of the themes used in the development of the framework and to further draw out other barriers that probably was not captured during the framework development.

This focus group evaluation comprised of three sessions with the researcher serving as the moderator of each session. The first session commenced with a brief presentation of the aims of the study, this was followed by an overview presentation of Lean Construction and the Last Planner system. In this session, the moderator explained to the entire group how the LPS framework being evaluated was developed. This session lasted for approximately 30 minutes and a coffee break of 10 minutes was observed.

The second session commenced after the participants reconvened from the break. This session was a hands-on practical session. The focus group participants in this session were divided into two subgroups of four random participants per group. Each group was given a demo project (FP1 and FP2) with the basic steps to executing the project listed in a sheet of paper and the LPS implementation steps listed for each project as shown in Figure 8.5, 8.6, 8.7 and 8.8.

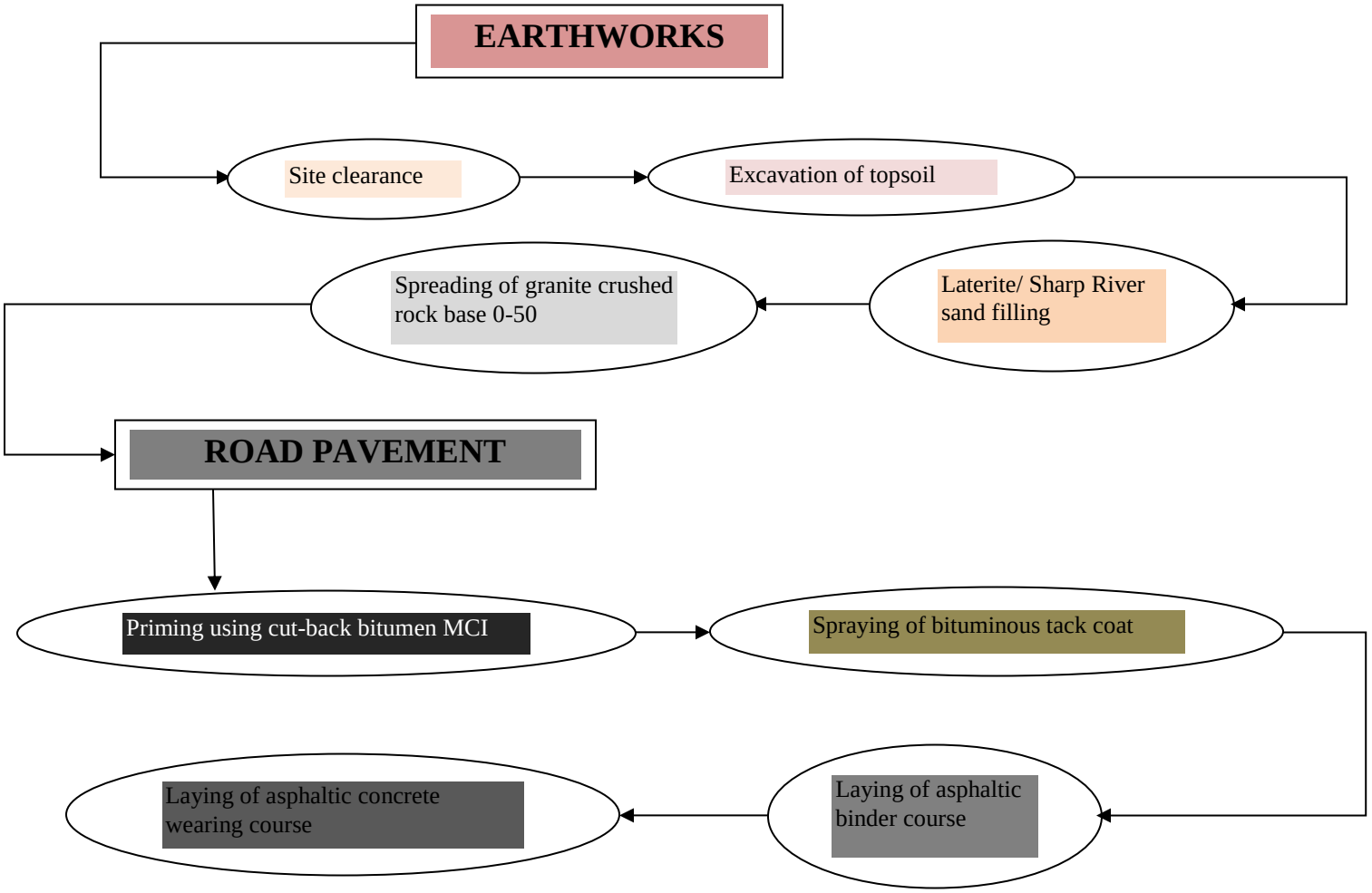


Figure 8.5 Demo Focus Group project for Road construction (FP1)

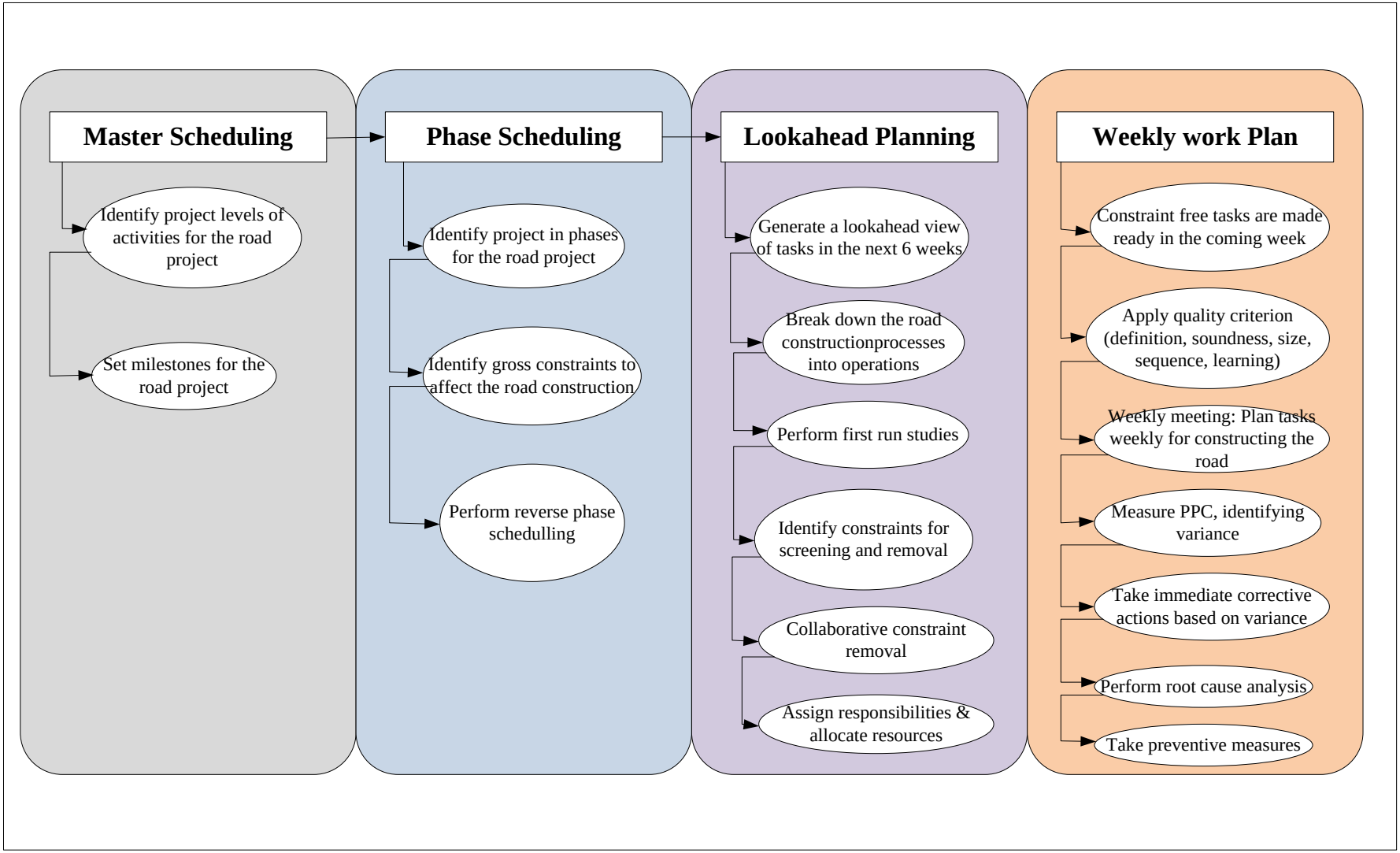


Figure 8.6 LPS implementation steps for the Road construction (FP1)

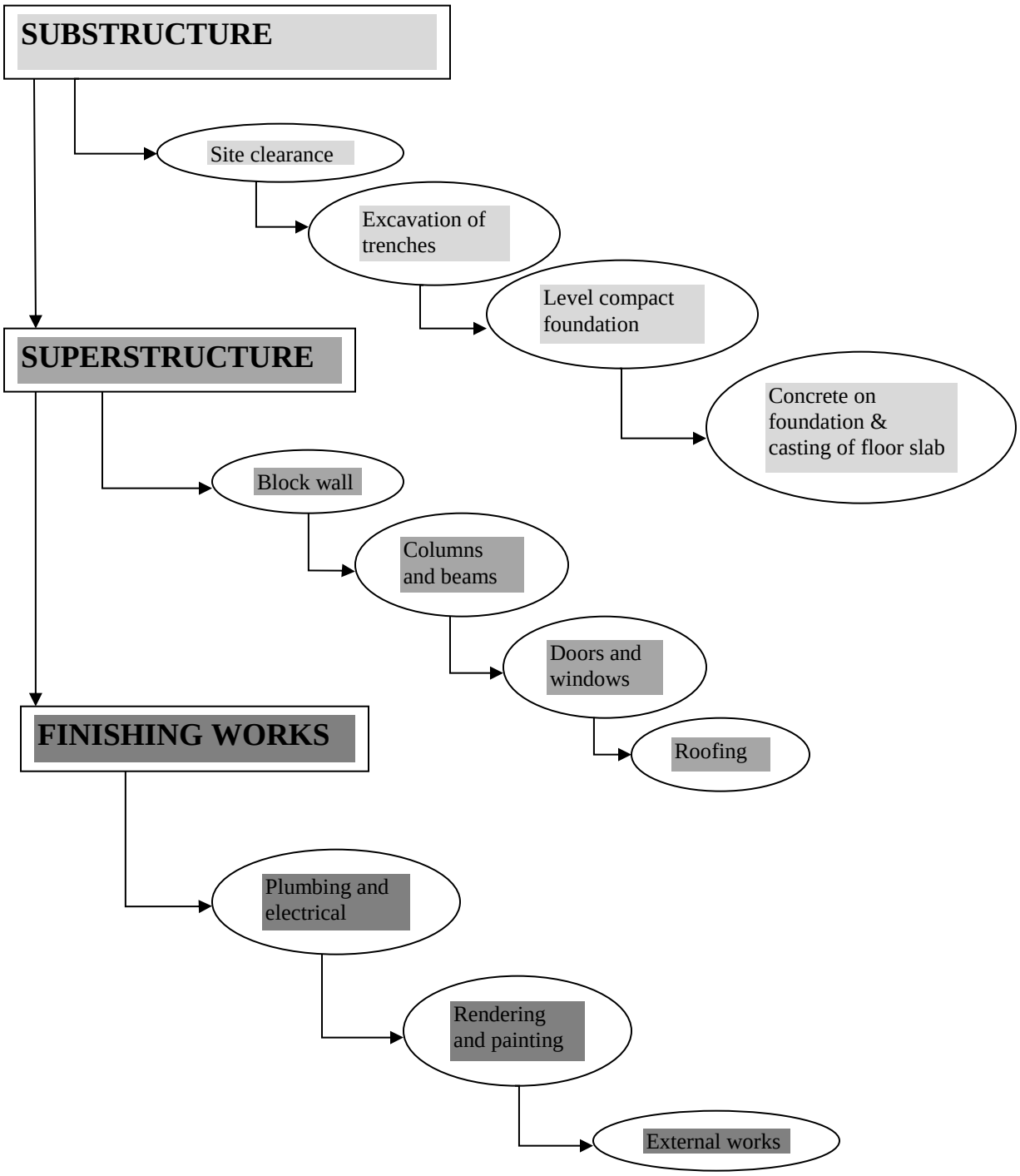


Figure 8.7 Demo Focus Group project for a building construction (FP2)

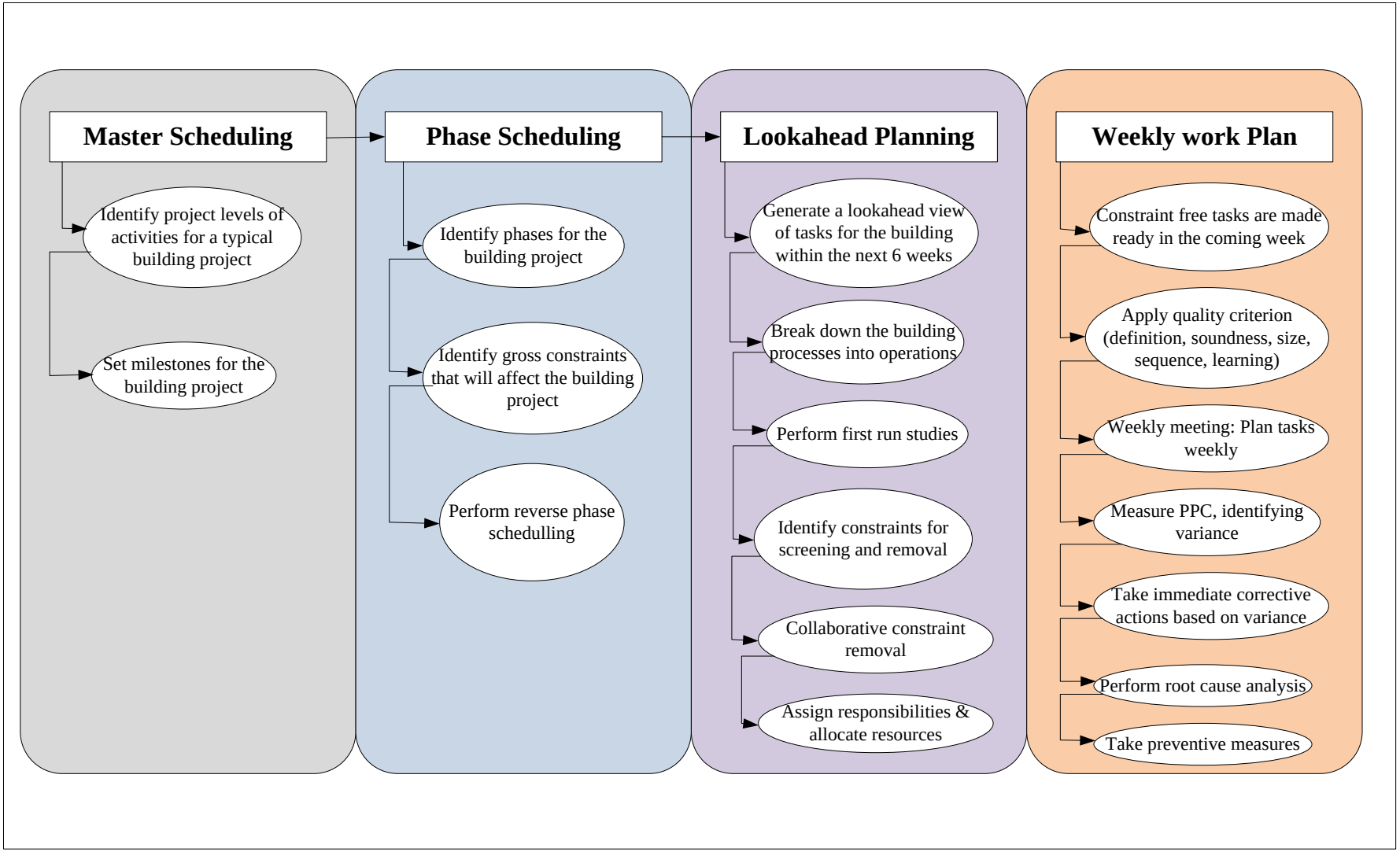


Figure 8.8 LPS implementation steps for the building construction (FP2)

Project 1(FP1) was a demo road project, while the second project (FP2) was a building project. The subgroup participants were allowed to discuss among themselves on the feasibility of successfully implementing LPS as listed based on the basic project steps identified. For the road project (FP1), the steps listed were: 1. EARTHWORKS - Site clearance, Excavation of topsoil, Laterite/ sharp river sand filling of the road carriage way, Spreading of granite crushed rock base 0-50; 2. ROAD PAVEMENT - Priming using cut-back bitumen MCI, Spraying of bituminous tack coat using colas "A", Laying of asphaltic binder course and Laying of asphaltic concrete wearing course.

For FP2 the steps listed were: 1. SUBSTRUCTURE - Site clearance, Excavation of trenches, Level compact and blind, Formwork and cast foundations, Backfill and casting of floor slab; 2. SUPERSTRUCTURE - Block wall, Columns and beams, Doors and windows, Roofing; 3. FINISHING WORKS - Plumbing and electrical, Rendering and painting and External works. These steps were used to match LPS process and further deliberated on by the participants on the effectiveness of the LPS in mitigating construction challenges faced in Nigeria. Each of the subgroup were given 20 minutes to deliberate among themselves on these issues, and they were then asked to swap projects (i.e. group discussing on FP1 were given FP2, and vice versa) while their deliberations were paying attention to the project at hand.

At the end of the practical session, all the participants reconvened together for the third session. Within this session, the moderator obtained diverse views to the limitations of implementing LPS on the two demo projects in the previous session. The moderator thereafter, introduced the proposed implementation framework, and also discussed how the themes within the framework were generated to mitigate the limitations of implementing LPS as identified by the participants. From the deliberations, additional themes were identified and other suggestions were made for

the successful implementation of LPS in Nigeria. The next section discusses the data collection and analysis methods used within this focus group.

8.6. DATA COLLECTION AND ANALYSIS

There are three main methods of collecting data during focus group research (Krueger and Casey, 2000). They are video recording, audio recording and note taking. Krueger and Casey, (2000) also explained that the three methods, could either be used together used within one focus group or two of the three methods used as well. Although the authors also stated that in some cases only one of the methods could be adopted for a focus group evaluation.

Conversely, in carrying out this focus group evaluation, data was collected using two methods: audio tape recording and note taking. The audio tape recorder was used in recording proceedings from the focus group sessions, while notes were taken intermittently by the moderator to record strong points made during each session. Finally, a simple 5 point Likert scaled questionnaire was handed to the participants so as to identify their opinions on the themes used to develop the LPS implementation framework proposed in this research.

Data obtained from the audio tapes were analysed using tape-based analysis, while those obtained from note taking were analysed using note-based analysis. The tape-based analysis required the researcher listening to the tapes over and over, so as to create an abridged transcript by focusing on the portions that assist in understanding the research questions. For the note-based analysis, the researcher analysed all the notes taken by comparing and verifying quotations of interest recorded with the tape. The note-based analysis also reviewed the reactions and non-verbal communications amongst the participants, which was recorded during the focus group session.

While the responses from the questionnaires were analysed through statistical frequencies, so as to match the information gathered from the notes as well as the tape recorder; and to further align the opinions of the participants on the issues raised from the focus group.

8.7. FINDINGS FROM THE FOCUS GROUP SESSIONS

All the participants were given the opportunity to discuss on the themes used in developing the proposed framework. Although most of the participants highlighted the themes were beneficial to the LPS implementation framework, nevertheless some other participants argued they were not beneficial and the last group not responding (either verbally or non-verbally). Table 8.5 illustrates the interaction of the eight participants and how they discussed on the themes.

Additionally, Table 8.6 shows the responses gathered from the questionnaires given out to the participants. It illustrated the frequency of influence the perceived themes would have on the implementation of the Last planner system in Nigeria.

Table 8.5 Interactions of the participants

THEMES		Beneficial	Non-beneficial	No Response
T1	The need to identify purpose	E1, E2, E4, E3, E5, E7	-	E6, E8
T2	The need to identify stakeholders impact	E1, E2, E3, E4, E5	-	E6, E7, E8
T3	The need for obtaining Sponsorship	E1, E3, E4	E2	E5, E6, E7, E8
T4	The need to build a cross-functional team	E1, E2, E3, E4, E5, E6, E7, E8	-	-
T5	The need to create measurement indices	E2, E3, E4, E5	E7	E1, E6, E8
T6	The need to organize training on Lean construction and the Last Planner System	E1, E2, E3, E4, E5, E6, E7	-	E8
T7	The need to create the right working climate	E1, E2, E3, E4, E5, E6, E7, E8	-	-

From the survey conducted and the responses obtained as highlighted in Table 8.6, all the themes had a frequency of 100% except ‘sponsorship’ and ‘creating measurement indices’ which had frequencies of 75% and 87% respectively.

However from the ranking of the themes using the relative importance index, (RII) also in Table 8.6; it was observed that the need to create the right working climate was ranked first. This was followed by the need to build a cross-functional team, followed by the need to organise trainings. This ranking showed the different levels of importance the respondent’s associated to the themes developed.

Additionally, the need to identify stakeholder’s impact was ranked fourth, while the need to identify purpose and the need to create measurement indices were both ranked fifth and sixth respectively. The RII indicated that the need to obtain sponsorship was ranked the list by the respondents.

Table 8.6 Presentation of answers to the questionnaire (Section 2)

s/n	Factors	weighting frequency (f)					$\sum f$	$\bar{x}$	RII	RANK	%Rating
		1	**2**	**3**	**4**	**5**					
1	*The need to identify purpose*	0	0	0	6	2	8	4.25	0.85	5th	100%
2	*The need to identify stakeholders impact*	0	0	0	3	5	8	4.62	0.92	4th	100%
3	*The need for obtaining Sponsorship*	0	0	2	6	0	8	3.75	0.75	7th	75%
4	*The need to build a cross-functional team*	0	0	0	1	7	8	4.87	0.97	2nd	100%
5	*The need to create measurement indices*	0	0	1	6	1	8	4.00	0.80	6th	87%
6	*The need to organise training*	0	0	0	2	6	8	4.75	0.95	3rd	100%
7	*The need to create the right working climate*	0	0	0	0	8	8	5.00	1.00	1st	100%

8.8. DISCUSSION OF THE FINDINGS

1. **Identify purpose:** It was observed that six (E1, E2, E4, E3, E5, E7) out of eight participants acknowledged that there was need to first identify the purpose of implementing the Last Planner System by any organisation wishing to implement it (Tables 8.5). According to a respondent:

   "…….identifying the purpose of a new process within any organisation, helps the organisation identify the need to carry out the new process…. In the company where I work, you must first justify everything to the management before it pulls through"

   Similarly, another respondent commented:
   "Knowing the aim or reason or need to do something new or differently, is a huge motivation to ensure the aim is met"

   While, another respondent highlighted:
   "identifying purpose entails objectively assessing the need to carry out the process prior to proceeding to adopt it……As you [the researcher] can see, there is need to make a case for LPS, with the aim of letting people see the reason why it should be implemented"

   Comments from the respondents suggest that the first step to implement the Last Planner System will be to clearly define the reason why it should be implemented within an organisation. Hence a clear case for LPS should be put forward to the management of the organisation and the case should be linked to the strategic goals of the organisation. Although the remaining two (E6 and E8) participants did not comment, they also did not object that the need to identify purpose was beneficial to the LPS implementation process.

   The relationship between each participant and the key words used for this test is illustrated in Figure 8.9.

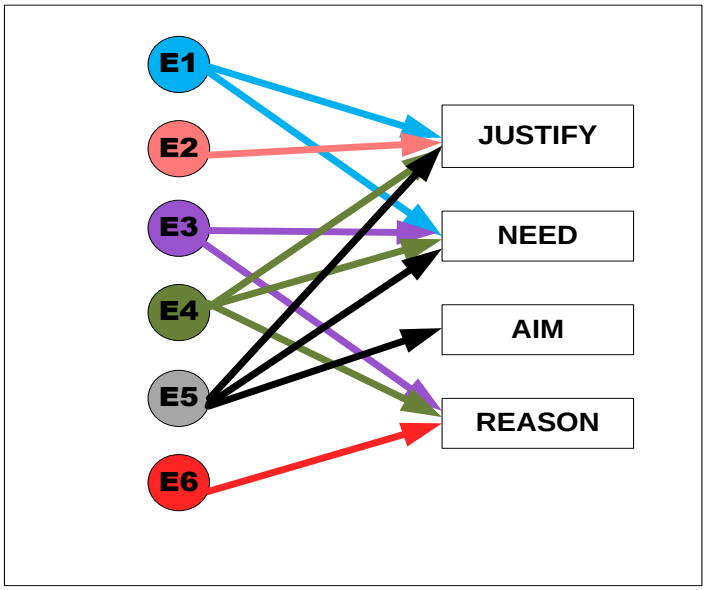


Figure 8.9 Relationship between respondents and key words in context of purpose identification (Testing phase)

These key words indicated that the respondents were in agreement with suggested driver. Their priority was on the order of NEED, JUSTIFY, REASON and AIM

Similarly, six of the same respondents agreed that if the purpose of the system is known to the organisation, it will improve communication within the organisation; this will in turn reduce lengthy approval procedures.

According to a respondent;

"..... knowing the purpose of the system, will improve commitment to the system. When workers are committed to any system, it resists cultural issues. In our company whenever a new procedure is introduced, the first thing they do is to ensure everyone is aware of what the new procedure hopes to achieve. This on its own improves quality control."

While another commented:

".... purpose creates zeal and removes bureaucracy".

Figure 8.10 illustrates the relationship between the respondent and the key words selected. These indicate that the respondents were in agreement that the model delivers what it was designed to do.

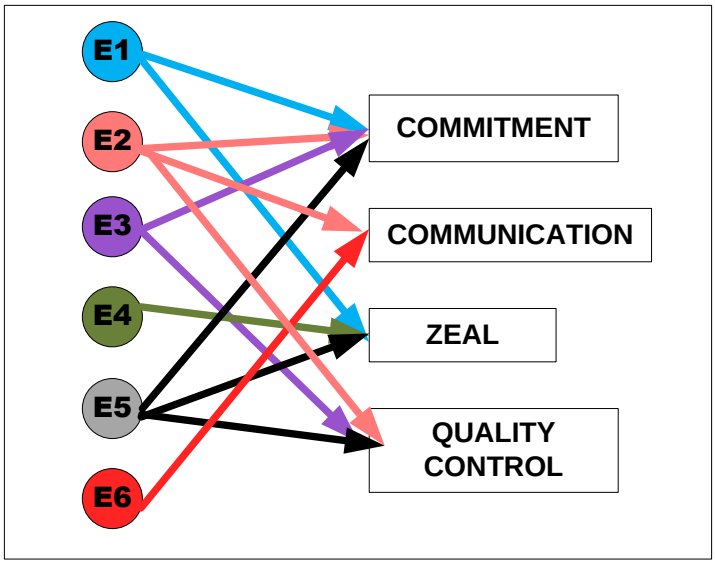


Figure 8.10 Relationship between respondents and key words in context of purpose identification (Evaluation phase)

2. **Identify Stake-holder's impact:** Five participants (E1, E2, E3, E4, and E5) from tables 8.5 acknowledged that identifying the positive impacts of adopting LPS to the stakeholders of the organisation, while the remaining three (E6, E7 and E8) did not respond. This positive impact is linked to the different stake holders that will benefit from the implementation within any project. For example, a respondent comments:

   "…….We have different levels of stakeholders and it is important for all of them to know how they will benefit from this new Last Planner System, so it will be accepted holistically as the project progresses".

   Another respondent also made a similar comment:

   "Different strokes for different folks".....there will be a variety of impacts that will emanate from this new process and all of these impacts should be stated to the different beneficiaries".

   All the five participants listed above made similar comments concerning the need to identify stake-holder's impact prior to the implementation of the LPS. Also, they stressed

that this was useful in the Nigerian construction environment to aid in the successful implementation of LPS.

The relationship between the respondents and the key words used to indicate that the respondents were in agreement with suggested driver as illustrated in Figure 8.11.

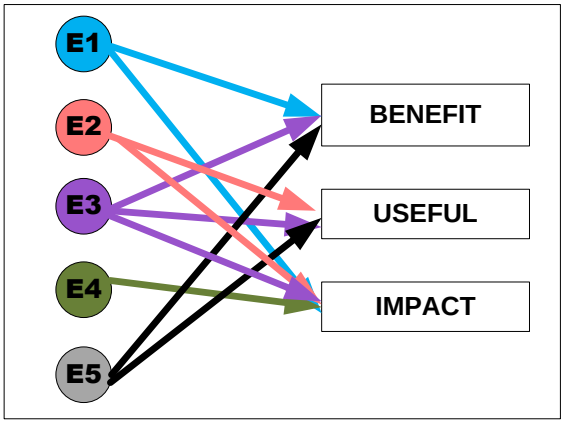


Figure 8.11 Relationship between respondents and key words in the context of stake-holder's impact (Evaluation phase)

Similarly, all 5 respondents acknowledged that the need to identify stakeholder's impact eliminates cultural issues, subcontractor's involvement and resistance to change. Additionally, figure 8.12 shows the link between the key words and the respondents used to establish the finding.

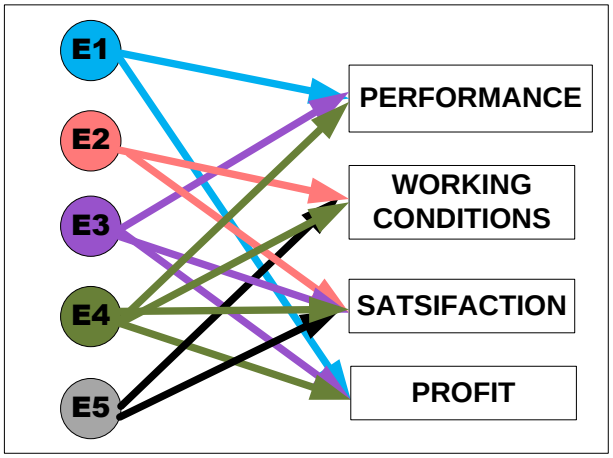


Figure 8.12 Relationship between respondents and key words in the context of stake-holder's impact (Evaluation phase)

3. **Sponsorship:** This was proposed by the researcher as an avenue to establish the right legal framework for development of LPS within a project. Three participants (E1, E3 and E4) assert that this was beneficial to the LPS implementation. One of the respondents stated that:

   '.....Sponsorship should be a major driver in the implementation of any new system".

   However, another participant (E2) had a contrary opinion. He argued that this was not to be added as an LPS implementation requirement. He comments:

   ".....introducing sponsorship as a driver for this implementation, has already been taking care of in the first and second driver discussed previously (identifying purpose and identifying stake-holders impact)".

   This argument presented by E2 was valid. However, the other three respondents further debunked the argument by stating categorically:

   "*....Sponsorship involves providing the support in terms of resources and logistics required during the implementation".*

   Figure 8.13 shows the relationship between the respondents and the key words used by the respondents. These key words formed the basis for suggesting that the respondents were in agreement with suggested driver.

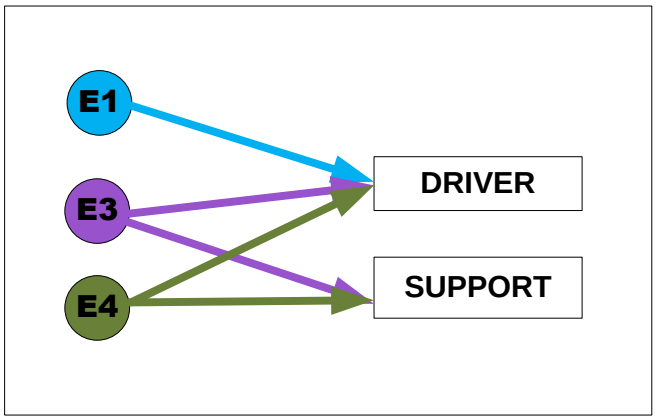


Figure 8.13 Relationship between respondents and key words in the context of sponsorship (Testing phase)

In the same vein, all three respondents E1, E3 and E4 agreed that obtaining sponsorship mitigates lengthy approvals and resistance to change.

One of the respondents stated that:

".....obtaining sponsorship from management for the new system, gives an assurance that management are in support of the system. Meaning the system will be useful to the project.....this usually serves as a driving force for us to accept the system."

Another respondent also stated that:

".....if management is paying for the system, then there will be no bureaucracy in giving approval for anything that concerns the system."

Figure 8.14 illustrates the relationship between the respondent and the key words selected to indicate that the respondents were in agreement that the model delivers what it was designed to do.

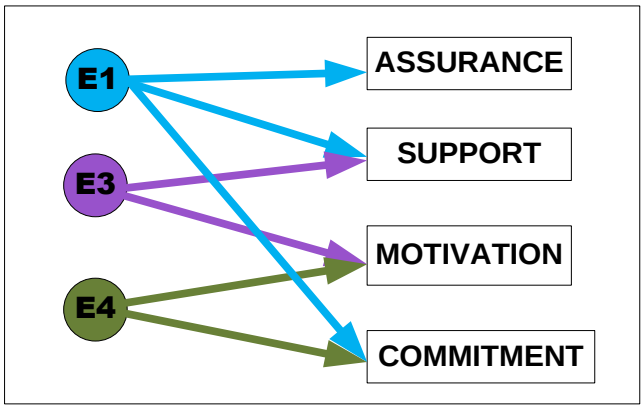


Figure 8.14 Relationship between respondents and key words in the context of sponsorship (Evaluation phase)

4. **Build a cross-functional team:** The need to build a cross-functional team was identified by the entire participants as being a very beneficial driver to the successful implementation of LPS. A respondent commented:

   "Having the right team is very vital to the successful implementation of this system and any other new developmental strategy or tool".

All the other respondents held the same opinion and had similar comments as the one described above.

Figure 8.15 illustrates the relationship between the respondents and the key words used to indicate that the respondents were in agreement with suggested driver.

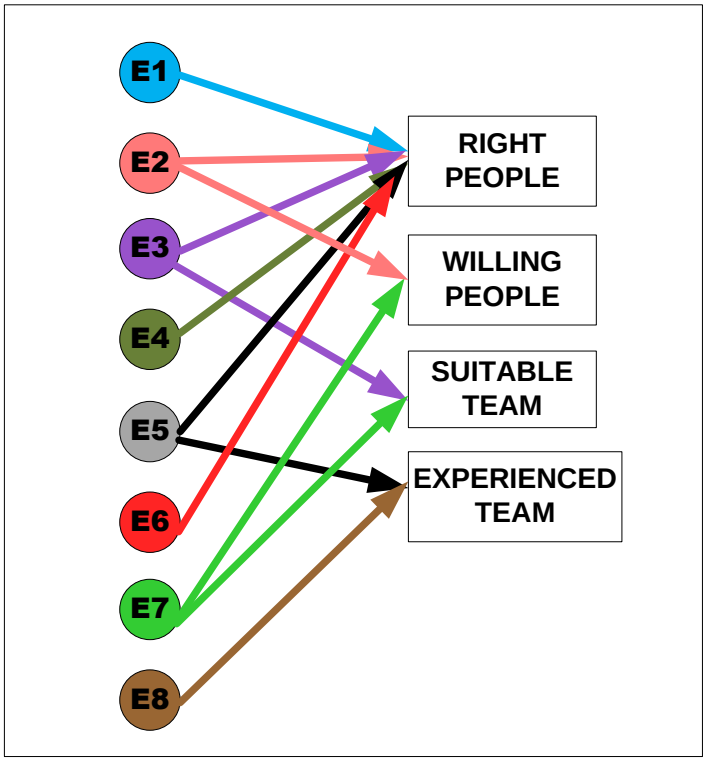


Figure 8.15 Relationship between respondents and key words in the context of building a cross-functional team (Testing phase)

All the respondents also stated that building a cross-functional team would help in mitigating the barriers of poor supervision and quality control, subcontractor's involvement and the resistance to change.

A respondent commented:

"*.....having the right team would make coordinating and supervising the project look seamless."*

This was the overall view of all the participants although, another respondent categorically stated that:

".....having the right team made up multi-skilled personnel makes even the team members so enthusiastic, that they are willing to perform tasks that would have ordinarily been given out as a sublet."

While another respondent added:

"*.....if you have the right team in place, they will be willing and eager to perform different tasks as long as it facilitates the project."*

Figure 8.16 illustrates the relationship between the respondents and key words selected to indicate that the respondents were in agreement that building a cross-functional team would mitigate the barrier of poor supervision and quality, subcontractor's involvement and resistance to change.

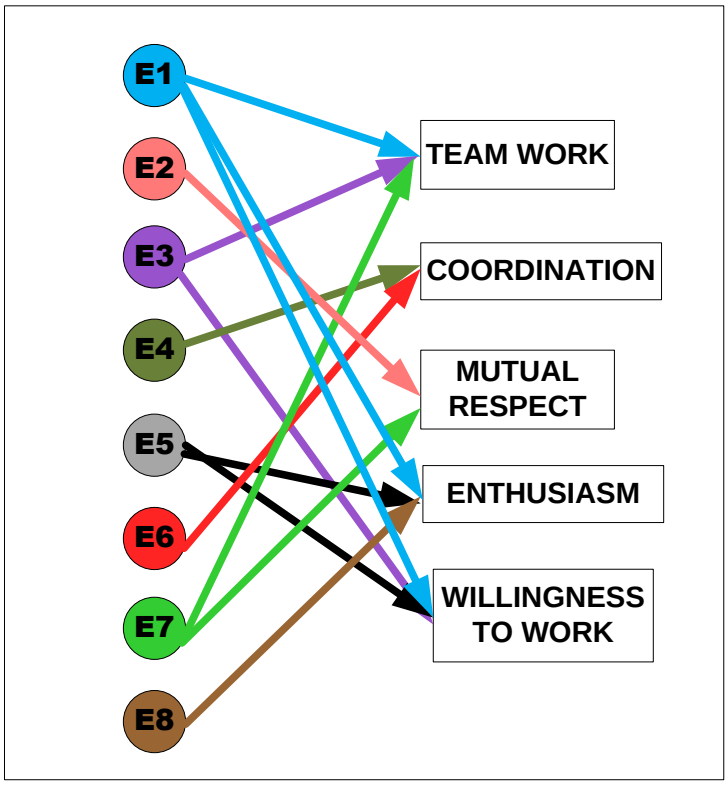


Figure 8.16 Relationship between respondents and key words in the context of building a cross-functional team (Evaluation phase)

5. **Creating measurement indices:** The need to create measurement indices was identified by four participants (E2, E3, E4 and E5) as positive driver for the implementation of the LPS in Nigeria. According to one of the respondents:

"*.....setting targets for improvement will only indicate if improvements have been made. In Nigeria we believe in results. These targets set should clearly be an indicator if we should proceed or drop the process".*

Similarly, another respondent commented:

".....Focusing on transitional gains using milestones is useful as it establishes a benchmark of accomplishments for the purposes of measuring progress".

However, a participant (E7) was of the opinion that creating measurement indices would not generally aid or serve as a driver for the implementation. On the other hand, three other participants (E1, E6 and E8) did not comment if it was beneficial or not.

Figure 8.17 shows the link between the respondents and the key words identified.

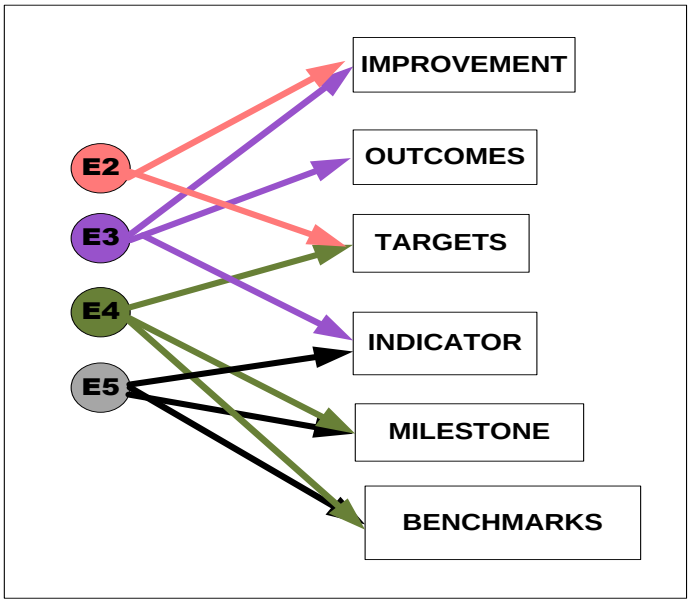


Figure 8.17 Relationship between respondents and key words in the context of measurement indices (Testing phase)

Similarly, the four respondents (E2, E3, E4 and E5) indicated that the need to create measurement indices reduces the barriers of lengthy approvals, fluctuations and variations and the resistance to change. Figure 8.18 illustrates the relationship between the respondents and the key words used to make these assertions.

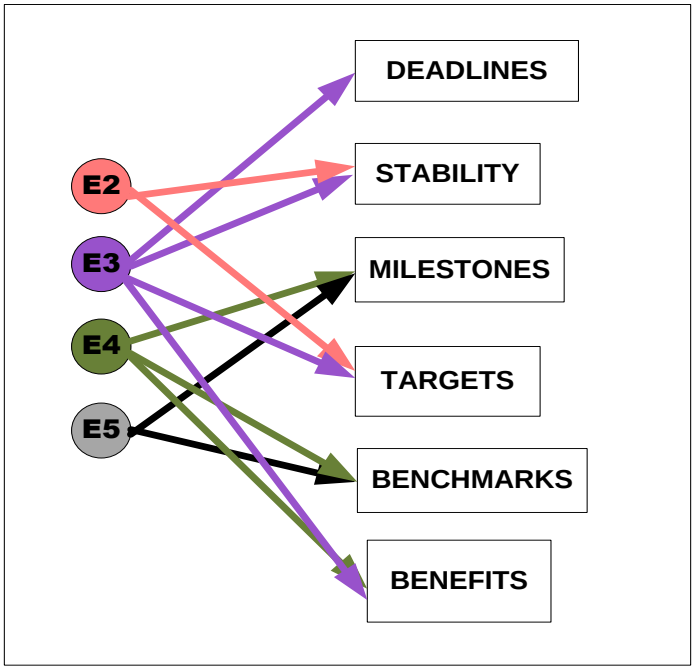


Figure 8.18 Relationship between respondents and key words in the context of measurement indices (Evaluation phase)

6. **Detailed training on Lean and LPS:** The need to organise trainings on Lean construction and the Last Planner System (LPS) from the reactions of the participants is a vital driver for the successful implementation of LPS in Nigeria. Seven participants (E1, E2, E3, E4, E5, E6, E7) indicated this, with a respondent commenting that:

   "*Within any organisation either in Nigeria or abroad, training is a vital key for progress….. An organisation's ability to train its employees, together with the employee's willingness to learn, if translated to rapid actions is the ultimate advantage it can ever possess".*

   Similarly, another respondent also commented:

"*....The importance of training cannot be over emphasised; it is the bedrock of any developmental achievements".*

Figure 8.19 shows the relationship between the seven respondents and the key words identified.

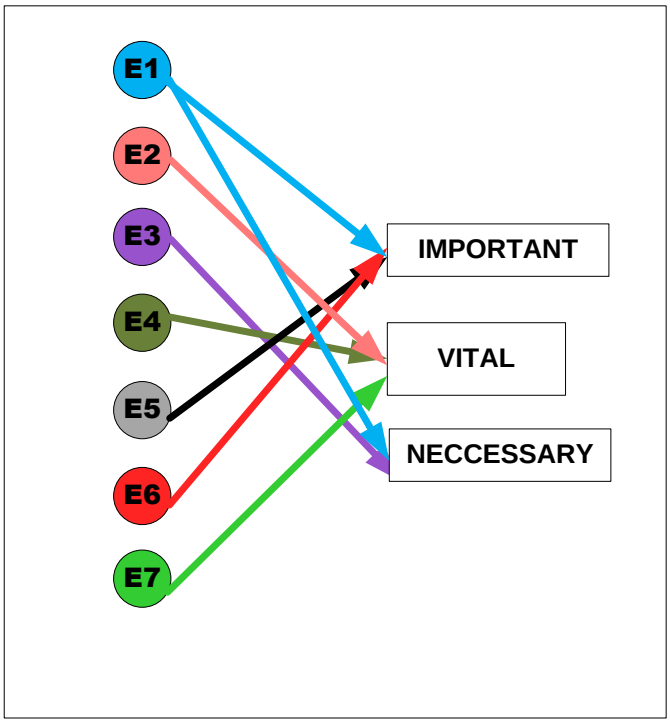


Figure 8.19 Relationship between respondents and key words in the context of training (Testing phase)

Furthermore, the 7 respondents also identified that if workers are properly trained on the lean concepts and the Last Planner system, challenges of resistance to change and cultural issues would be overcome.

A respondent noted:

"*.....workshops and training programs sensitises workers on new initiatives and in most cases these workers are willing to try out what they have learnt from the trainings."*

Another respondent agreeing indicated that:

"*.....training programs on its own serve as a change initiative because, knowledge is gained through training and if the knowledge is applied change occurs."*

In the same vein, another respondent said:

"*.....enlightenment campaigns are a practical learning medium and it serves as a means to minimise resistance to change.*"

Figure 8.20 illustrates the relationship between the respondent and the key words selected to indicate that the respondents were in agreement that the model delivers what it was designed to do.

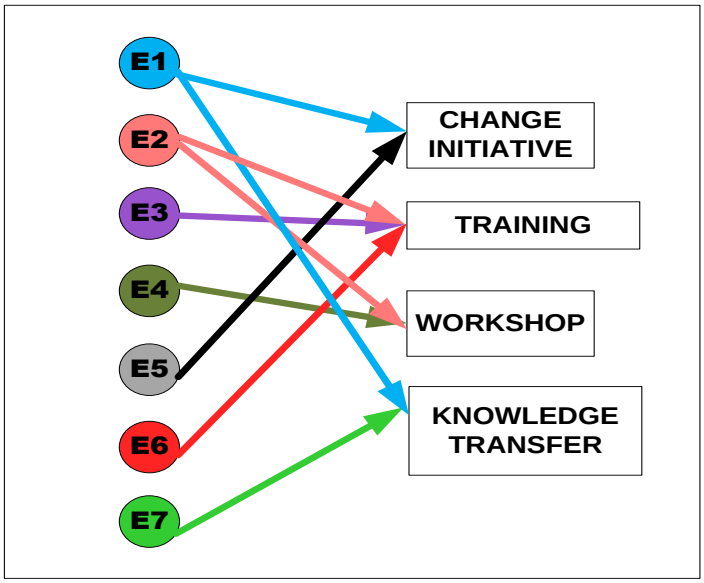


Figure 8.20 Relationship between respondents and key words in the context of training (Evaluation phase)

7. **Create a working climate:** All the participants (E1, E2, E3, E4, E5, E6, E7 and E8) were of the opinion that creating a working climate would be a very beneficial driver to the successful implementation of LPS in Nigeria.

   Figure 8.21 illustrates the link between the respondents and the key words used to indicate that the respondents were in agreement with suggested driver.

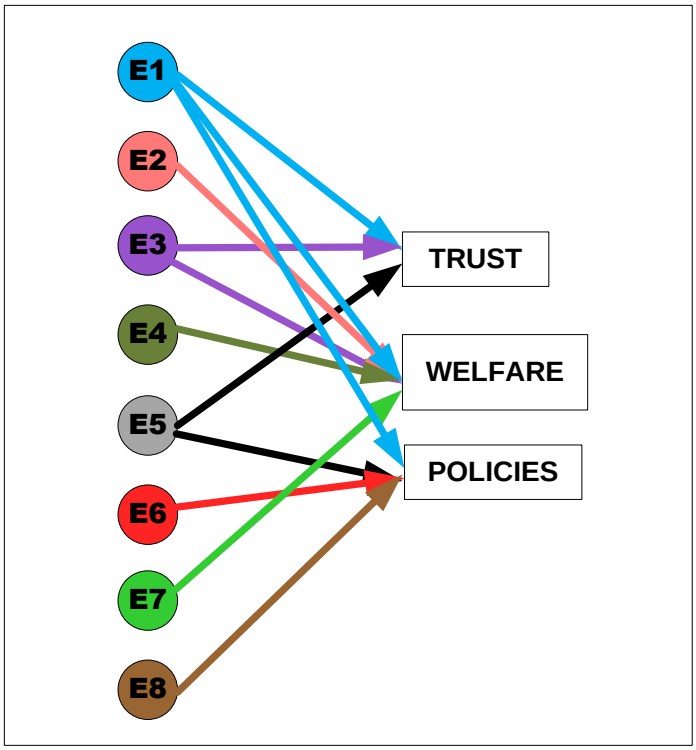


Figure 8.21 Relationship between respondents and key words in the context of creating a working climate (Testing phase)

Similarly, all eight respondents agreed that creating a working and enabling climate would help mitigate barriers like: cultural issues, resistance to change, subcontractor's involvement, fluctuation and variation.

A respondent commented:

"*....if an enabling working environment is in place, it would motivate the workers and they will even be willing to carry out activities that would have been subletted."*

Another respondent commented:

"*.....when the right policies are in place it creates an enabling environment where bureaucracy and variation is minimised."*

Figure 8.22 illustrates the relationship between the respondents and the key words used in showing that the respondents were in agreement that the driver delivers what it promises to.

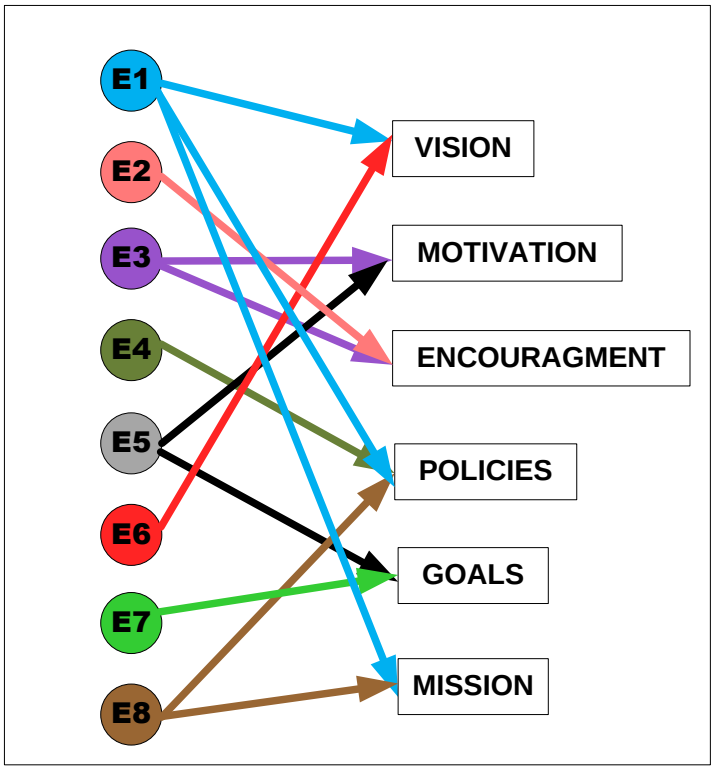


Figure 8.22 Relationship between respondents and key words in the context of creating a working climate (Evaluation phase)

8.9. CHAPTER SUMMARY

In evaluating the Last Planner System (LPS) implementation framework developed from this research, a focus group discussion was adopted. This chapter describes how the evaluation process occurred with eight different construction professionals. These professionals discussed on the proposed LPS implementation framework. They argued on how suitable the themes of the framework would fit into the Nigerian context. The findings were discussed and it was revealed that most of themes proposed were appropriate for the framework, although one or two participants had their reservation on some of the themes.

9. Chapter Nine - CONCLUSION AND RECOMMENDATION

9.1. INTRODUCTION

This chapter is aimed at concluding the research by returning to the research question and objectives as they were originated in the first chapter. It provides a general explanation of the research questions and establishes whether the results meet the research objectives. Furthermore the contributions to knowledge made by this study are discussed in detail followed by the review of potential future research work and the impact that the approach developed in this study could make to industry practice. Finally, the research limitations and recommendations are presented.

9.2. OVERVIEW OF THE RESEARCH

A general overview of the entire research is given in Figure 9.1. The research process started by identifying the need to undertake the research; this formed the aim and objectives of the research which is stated in chapter one. Chapter two focused on the Nigerian construction industry. It indentified the inherent problems associated with the Nigerian construction industry; reviewing what other researchers have done in that regard. It was revealed that only exploratory studies were conducted identifying the problems and possible solutions without actually practically testing any improvement techniques.

This research identified the Last Planner System as a Lean Construction tool, which is used to improve planning and control, develop work plans in details, identify and remove constraints before they occur and increase reliability of work plans. The Last Planner system was implemented via an action research in construction projects in Nigeria.

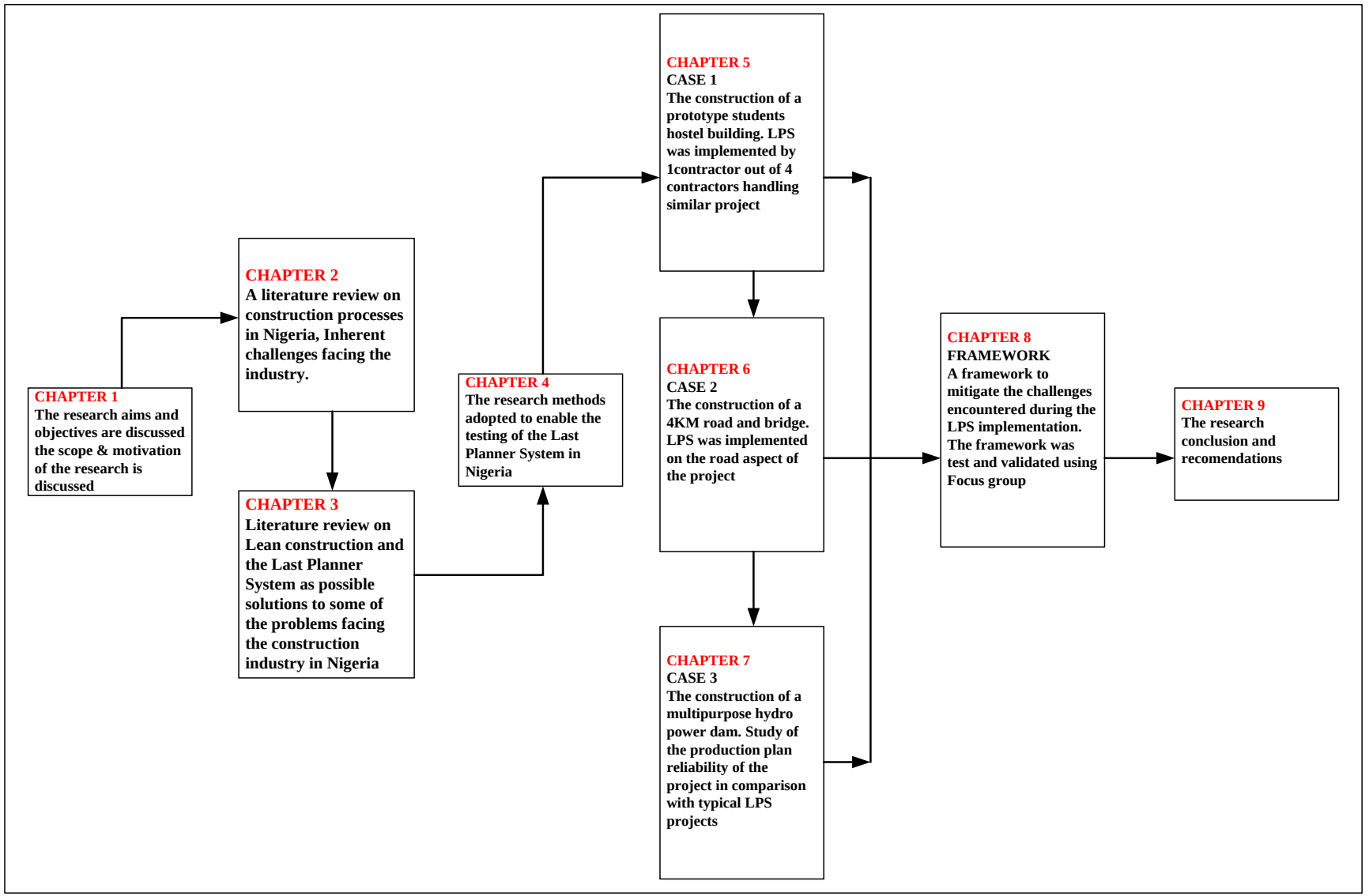


Figure 9.1 Detailed illustration of the entire research process

The Nigerian construction industry as highlighted in chapter two is beclouded with inherent problems which impair its performances. These inherent problems according to Oyewobi *et al.*, 2011; Olusegun and Michael, 2011; Oke and Ogunsemi, 2011; Aina and Wahab, 2011; Windapo and Martins, 2010; Oke and Ogunsemi, 2011; Dlakwa and Culpin, 1990; includes: complexity of project; faulty defective working drawings; lack of proper tools and equipment's by contractors; incomplete specification; resistance of client to changes; budgetary limitations; non-standardization of design; lack of construction experience by the client; poor communication; lack of mutual respect between the designers and contractors; inadequate planning; inflation; bankruptcy of contractor; variation of project scope; political factors; death of client; incompetent project manager; wrong estimate; inadequate cost control; delayed payment of contractor and suppliers; poor contracting documents; lack of transparency; presence of unqualified individuals; decline in competence of trained professionals and artisans; unforeseen ground conditions.

Nevertheless, these problems were classified in chapter two and linked to barriers hindering the implementation of change initiatives within the industry. Six major barriers were identified which include: supervision and quality control, fluctuation and variations, subcontractor involvement, resistance to change, cultural issues, and lengthy approvals. These six barriers were measured in case study one and two and also ranked in averages of their degrees of occurrence. The findings from the rankings showed that the major barriers were cultural issues and resistance to change, while the others were; lengthy approval, subcontractor's involvement, poor supervision and quality, fluctuations and variations.

Consequently, the research integrated elements of previous studies to develop a framework to facilitate the effective implementation of the LPS in Nigeria. Furthermore, the framework was validated using a focus group research and it revealed the potential of the framework to facilitate the implementation process as proposed.

9.3. ACHIEVING THE RESEARCH QUESTIONS AND THE RESEARCH OBJECTIVES

The research seeks to relate this conclusion to the purpose of the initial inquiry, which was framed in this question:

> *Can the Last Planner System, a lean construction tool be successfully applied to improve construction processes within Nigeria?*

In answering this question, LPS was implemented in two different case projects, at different geographical locations in Nigeria. The first case project, the construction of the prototype student's hostel was located at the north central axis of the country. While, the second project, which entailed the construction a 4 Kilometre single carriageway road and an 80 meters span bridge was located at the southern part of the Nigeria.

Although the LPS process within both projects started off slowly, it was successfully implemented and it produced the desired results of improving the general performance of both projects. For instance, the first case study which entailed four contractors handling four prototype projects for a University (see Chapter 5). Only one contractor participated in the LPS implementation process and the contractor produced substantial results in terms of time, cost and quality performances as he had a better allocation of resources, organised work flow and a reliable work plan.

Similarly, in the second case project, the main contractor handling the entire project acknowledged that they had no previous knowledge of Lean Construction or the Last Planner System. The contractor also had a history of not completing their projects on time and within the project cost. However, for this 4 kilometre road, the contractor decided to adopt LPS and it was recorded that they were able to resolve issues on site before they escalated, improved site logistics, created predictable and reliable work programs and improved the safety of workers within the project.

Thus in answering the research question, both case studies were used to investigate if LPS could be applied in construction projects in Nigeria. From both case studies it can be categorically said that LPS can be implemented in similar construction project in Nigeria. Additionally, both case projects recorded improvements from the implementation of LPS hence it can also be said that LPS can improve construction processes in Nigeria.

From the first case study, the entire project was initially characterised by unavailable material and labour, poor coordination of site activities, poor planning and control, communication challenges, adversarial relationships and the fragmentation of the entire construction process. These were typical to the characteristics of the Nigerian construction industry. However, the outcome from the first case study after the implementation of the LPS reveals that the contractor who implemented LPS in comparison with other contractors performed much better in terms of time, cost and quality performances thereby producing the expected results of LPS projects.

In the same vein, the second case study (the 4 kilometre road project) was characterised by poor planning, incomplete designs and the fragmentation of the entire construction processes. Conversely, following the LPS implementation the road project was completed on schedule and at reduced cost.

Consequently, it can be inferred that despite the unique nature of the Nigerian construction industry, LPS implementation within projects in Nigeria showed similar results as presented in the literature review of improving workflow reliability, improving planning and control, achieving project duration reduction, and improving cost and quality performances.

9.3.1. ACHIEVING THE RESEARCH OBJECTIVES

The different objectives set out in chapter one are reviewed against the work completed. The review of each objective assesses whether the aim has been achieved. Five objectives were set out with a research aim of evaluating the effectiveness of implementing LPS in solving

the inherent construction challenges in Nigeria. The research objectives as originally set out are:

1. *To critically review literature on Nigerian construction processes, identifying inherent problems facing the construction industry.*
2. *To critically review Lean Construction and Last Planner implementations in other countries, drawing up the possible barriers of LPS that could be experienced in Nigeria in addition to the inherent problems of the Nigerian construction industry.*
3. *To implement LPS in multiple construction projects in Nigeria and measure the barriers identified from the literature reviews as possible barriers to the implementation*
4. *To compare typical LPS projects with a successful construction project in Nigeria, to identify similarities and differences between both processes.*
5. *To develop, test and validate a framework for the effective implementation of LPS in Nigeria to mitigate the barriers to LPS identified.*

A summary of how the objectives relates with each chapter is described below:

- Objective one – CHAPTER TWO
- Objective two – CHAPTER THREE
- Objective three – CHAPTER FIVE AND SIX
- Objective four – CHAPTER SEVEN
- Objective five – CHAPTER EIGHT

1. To critically review literature on Nigerian construction processes

A comprehensive review of literature is conducted to satisfy the criteria set out in this first objective; the review identified the inherent problems facing the Nigerian construction industry causing the industry to perform below standards in terms of time, cost and quality (see chapter 2, section 2.4). It was also revealed from the reviews that the root causes to these problems continually impaired the performance of the industry. This occurred even when improvement initiatives were suggested they met stringent barriers. Hence, these root causes include poor project definition during planning, inadequate

funds, inflation, bankruptcy of the contractor, variation on the project, death of client, political factors, wrong estimates etc.

2. To critically review Lean Construction and Last Planner implementations

This research objective was met after an intriguing review on Lean Construction and Last Planner implementations in other countries. The barriers experienced during the implementation of LPS in different projects were identified and linked to inherent problems of the Nigerian construction industry. These barriers where then categorised and grouped to include: resistance to change, cultural issues, supervision/quality control, fluctuation and variation, sub-contractors involvement and lengthy approvals.

3. To implement LPS in multiple construction projects in Nigeria

This third objective also answers the research questions and this forms the centre focus of this research. In order to achieve this research objective, the LPS was implemented via an action research, in two construction projects in Nigeria and the findings from the second objective (possible barriers of LPS implementations from literature) were used to measure the barriers of implementing LPS in Nigeria. These barriers include: cultural issues, resistance to change, lengthy approval, subcontractor's involvement, poor supervision and quality control, fluctuations and variations

The finding revealed that cultural issues and resistance to change were the dominant barriers to LPS in Nigerian projects. Although other barriers are still present which include lengthy approvals, sub-contractors involvement, supervision and quality control, fluctuation and variations.

4. To compare typical LPS projects with a successful construction project in Nigeria

This objective was met by investigating the state of production plan reliability of a successful project in Nigeria; the construction a multipurpose hydro-power dam project.

The findings from the investigation were compared against typical LPS projects to identify the similarities and differences within the projects. It was revealed that there was a huge similarity in the way the dam projects and LPS projects were planned, controlled and managed. This was in terms of site logistics, collaboration, learning and relationship building.

While the differences observed were on the way tasks were scheduled and managed. For the dam project, the tasks were scheduled based on a practical planning system utilised by the PM while LPS promotes pull planning. Furthermore, the dam project had no precise project management technique which could be documented and recommended for use, while the LPS has a laid out procedure on how to implement it on any project.

5. To develop a framework for the effective implementation of LPS in Nigeria

This objective was achieved when a framework was developed to aid the effective implementation of LPS in Nigeria. The framework draws on experience from previous implementations identifying LPS implementation barriers and devising a guideline for the successful implementation of LPS within construction projects in Nigeria. It highlights different elements that should be considered before implementing LPS in Nigeria. Furthermore, the framework was tested and validated by practitioners in a focus group discussion. The findings from the focus group revealed that the themes proposed in the framework were suitable to facilitate the implementation of LPS.

9.4. CONTRIBUTION TO KNOWLEDGE

Throughout the work undertaken in this study, several contributions have been made to the existing body of knowledge and understanding. The main areas of this contribution to knowledge in construction management practice is summarised in the following subsections.

1. **Using DSR to implement LPS in a new and challenging environment, Nigeria.**

   This study has contributed to exciting body of knowledge by introducing and adopting DSR a novel research methodology that goes beyond the normal explanatory or descriptive or traditional research methodologies. DSR was adopted via an Action Research by practically implementing LPS in two construction project in Nigeria. The Nigerian environment as identified in chapter 2 is characterised by fragmentation, antagonism, mistrust, poor communication, competition, blame culture and lack of accountability. These characteristics are unique to the Nigerian construction industry, thereby making it a challenging environment. Hence the implementation was able to improve the project management practice from a very low level of systematic project management to a more organised system.

2. **Providing improvements to construction practice within the study organisations**

   This contribution relates to the practical benefit realised within case studies 1 and 2. This was achieved through active collaboration between the research and the study organisation. Consequently, the results from the cases revealed that the LPS identified and addressed potential problems before they became obstacles; created predictable and reliable production programs; improved construction logistics at site; improved the prediction of labour and delivered the project faster and at reduced cost.

3. **Establish a link between LPS and other successful projects**

   Another major contribution to this research is the rich insight gained in chapter 7 on the relationship between a successful project and a typical LPS project. The finding of the case study (the construction of a hydro power dam project) revealed that there was cooperation between different project participants, coordination of the site activities,

open and free communication channel, good leadership, a high level commitment from production units and the motivation of workers.

From the comparison with the LPS projects, it was observed that similarities existed in the way the project were planned, controlled and coordinated which led to the dam project having a similar outcome to an LPS project. These outcomes included; improved construction logistics, collaboration, transparency and trust, reliability of scheduling and delivery of value while, consuming the fewest resources.

In a nutshell, if a project is thoroughly planned and properly controlled, and if the stakeholders and project participants are properly carried along, it could yield to positive results in the project.

4. **Offer a framework that will serve as a guide for the successful implementation of LPS in Nigeria**

It was observed that no previous research has put forward a framework for the effective implementation of LPS in Nigeria. Hence this research is considered a pioneer study in the development of an LPS implementation framework in the Nigerian environment. As seen from the previous sections, the framework in conjunction with LPS promises to make Nigerian construction projects more predictable, reducing uncertainties, creating reliable work plans and improving collaborative planning.

Additionally, the findings indicated that the framework provides a dynamic view of the factors that can increase the effective implementation of LPS in a challenging environment like that of Nigeria.

Another contribution to knowledge is that the framework serves as a guide to practitioners particularly project manager in setting up strategic plans to successfully implement LPS in Nigeria.

The contribution made by this research is timely as the Federal Government through the federal ministry of Works is now urging stakeholder's especially local indigenous contractors to embrace different construction improvement and change initiatives and also suggest other improvement initiatives that would foster progress within the industry. This research thus bridges the gap between theory and practice while solving managerial problems in the field of construction.

9.5. RESEARCH LIMITATIONS

This research has a few limitations that need to be stated:

1. This study is limited to the Nigerian construction industry. Nevertheless, some of the research findings are likely to be the same in West African countries and other emerging economies with similar challenges in its construction sector like those highlighted in this research.
2. Another limitation is the implementation of LPS in only two construction projects, being handled by indigenous construction companies.
3. A third limitation of this research is the use of only one project as a successful project to measure similarities and differences between the project and LPS projects. Making it difficult to generalise the findings.

   However, to generalise this entire research, additional research is required and the next section concludes and advocates for further research to address these limitations.

9.6. CONCLUSION:

The conclusion of this research is summarised as follows:

Lean construction is a change initiative which seeks to improve construction project's performances through the application of lean tools especially the Last Planner System. Thus Design Science Research, a research methodology advocated by Lean Construction practitioners is adopted to implement a solution that can bring about change to a phenomenon using an Action Research approach. Action Research approach as it stands is inherently a change oriented approach in which a process is studied and change is introduced and observed.

In view of these LPS was implemented in two construction projects to serve as a change initiative improving the performance of the projects in terms of time, cost and quality. The findings from the implementation revealed that implementing LPS within both projects created predictable and reliable project plans and in full detail, identified and removed constraints before they became obstacles, improved logistics at site and completed the projects with project duration and cost.

Similarly, comparing a successful project handled by a multinational firm in Nigeria with typical LPS projects identified from literature reviews showed a lot similarities in terms of project outcomes. Although differences existed in the way both projects were managed.

Nevertheless, during the LPS implementation within first two case projects, the following huddles were confirmed as anticipated from the literature reviews: cultural issues, lengthy approvals, resistance to change, supervision and quality control, sub-contractors involvement, fluctuations and variations.

Accordingly, a frame work is developed to overcome these huddles identified. Themes used in the development of this framework included; need to identify purpose, need to identify stakeholders impact, need to obtain Sponsorship, need to build a cross functional team, need to create measurement indices, the need to create a right working climate and the need for training on Lean techniques and LPS.

This framework was further validated by industry practitioners within the field of the study and positive feedbacks were obtained from the focus group discussions.

9.7. RECOMMENDATION

The following recommendations are suggested in this research.

1. The proposed framework is not a pick and choose tool box or a rigid step by step framework, rather it is a guideline as to what should be in place to promote the successful and effective implementation of LPS.
2. The study advocates for the proper implementation of LPS holistically within any project so as to fully enjoy all the benefits LPS promises.
3. Implementing LPS is usually a lengthy and sometimes a cumbersome process, although it promises to improve planning, control and coordination. Hence it requires a lot of commitment and patience from practitioners seeking to implement it for the first time, knowing that planning and control are dynamic and iterative processes.
4. Construction management research should be able to solve problems within its field. Hence it is recommended that Design Science Research approaches be adopted rather than conducting only descriptive and exploratory studies which are not enough in solving managerial problems in construction.

9.8. FURTHER RESEARCH

Further research should focus on the holistic barriers of implementing LPS and developing of a universal implementation framework that can fit into any construction environment. In the same vein, further research should be made on applying the same research in other developing countries.

Similarly, additional research should be made in the adoption of other Lean Construction tools and techniques within Nigeria. While further research should be developed to address the research limitations highlighted in this thesis.

In spite of the fact that the framework developed in this research facilitates the implementation of the Last Planner System in Nigeria, a tool kit and implementation guide should be developed to further ease the implementation of LPS and Lean Construction in Nigeria.

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APPENDICES

APPENDIX I – COVER LETTER TO PARTICIPATE IN ACTION RESEARCH

School Of Technology

Dean:
Professor R Moreton BA(Hons) MTech FBCS CITP ILTM

School of Technology
University of Wolverhampton
Technology Centre
MI Building
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Wulfruna Street
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Dear Sir,

REQUEST FOR RESEARCH PARTICIPATION ON IMPROVING NIGERIAN CONSTRUCTION PRACTICE

As part of a research being undertaken by the University of Wolverhampton on improving construction project management practice in Nigeria using a Lean Construction technique called the Last Planner Systems™, (LPS) we request your participation.

The Last Planner Systems™, (LPS) has been applied in numerous projects around the world within the past two decades has been a useful means of improving the delivery of projects in terms of time, cost and quality. This research aims to explore the potential benefits adopting LPS within construction projects could improve the delivery of projects in Nigeria.

Research of this nature largely depends on contribution from industry experts. Thus, as a key player in the Nigerian construction industry access to any of your projects is fundamental to the success of this research. I would be very grateful if I could gain access to one of your on-going projects for a case study at no cost to your organisation.

This would involve interviews with key project participants, non-participant observations and attendance of project team meetings. The interviews, questionnaires and any other data gathered would be STRICTLY CONFIDENTIAL and used for research purposes only. At no instance would the true identity of any interviewee or organisation be likened to any responses provided and the entire research would be conducted in accordance with the University of Wolverhampton's ethical and safety guidelines for fieldwork.

In return for your participation, the research findings will be made available to you and the outcome of the research could have the potential of improving project planning and the delivery of the project in which the LPS would be applied on time, within budget minimising wastes and inventory. I am willing to comply with any requirements or negotiate terms that deem necessary in accordance to your company regulations.

The other members of the research team are Dr. David Oloke, Dr. Subashini Suresh and Prof. Jamal Khatib all from the University of Wolverhampton, UK. I can be reached anytime via my email [e-mail address redacted] or my cell phone [number redacted] or [number redacted].

I will be very grateful if your organisation is willing to participate in this research.

Yours sincerely

Ograbe Ahiakwo

(PhD Researcher)
University of Wolverhampton, UK

APPENDIX 2A – Interview for Case study 1

Section A- ***Introduction***

1. **What is your current designation within your organisation?**
2. **How long you have worked in the construction industry?**
3. **How long have you been with the organisation?**
4. **What is the type and size of the projects your organisation mostly engages in?**

Section B- ***Project management Practice***

1. **What organisational structure is in use in your company?**
2. **What is the organisational culture of your company?**
3. **Is the culture consistent with the current objectives and policies of the company?**
4. **Describe the project planning technique that is used in your organisation?**
5. **What Project management systems in place?**
6. **Who are key players/ participants involved in the planning and control process of your organisation?**
7. **How frequent do you meet to review and update project plans?**
8. **How often do you have planning and site meetings during construction processes?**
9. **How often do you rely on subcontractors and to what extent?**
10. **Who plans and coordinates the program or schedule at the site?**
11. **How is Labour, material and plants coordinated at site?**
12. **What criteria do you use in judging a successful project?**
13. **What kind of communication tools do you use during the construction process, i.e. Communication gadgets and tools used on site?**
14. **Describe your understanding of the term "Lean Construction"?**

APPENDIX 2B – Interview for Case study 2

Section A- ***Introduction***

5. **What is your current designation within your organisation?**
6. **How long you have worked in the construction industry?**
7. **How long have you been with the organisation?**
8. **What is the type and size of the projects your organisation mostly engages in?**

Section B- ***Project management Practice***

15. **What organisational structure is in use in your company?**
16. **What is the organisational culture of your company?**
17. **Is the culture consistent with the current objectives and policies of the company?**
18. **Describe the project planning technique that is used in your organisation?**
19. **What Project management systems in place?**
20. **Who are key players/ participants involved in the planning and control process of your organisation?**
21. **How frequent do you meet to review and update project plans?**
22. **How often do you have planning and site meetings during construction processes?**
23. **How often do you rely on subcontractors and to what extent?**
24. **Who plans and coordinates the program or schedule at the site?**
25. **How is Labour, material and plants coordinated at site?**
26. **What criteria do you use in judging a successful project?**
27. **What kind of communication tools do you use during the construction process, i.e. Communication gadgets and tools used on site?**
28. **Describe your understanding of the term "Lean Construction"?**

APPENDIX 3A - QUESTIONNAIRE FOR CASE STUDY 1

Section A

Please use the scale below to answer the following questions below by marking **X**. the rating scale 1 - 5 represent the frequency of occurrence;

1 – strongly disagree; 2 – disagree; 3 – neither agree or disagree; 4 – agree; 5 – strongly agree

		1	**2**	**3**	**4**	**5**	
1	LPS was very effective within this project						
2	The results achieved from the implementation are they satisfactory from your previous projects						
3	The Weekly Work Plans & PPC were very useful						
4	It was difficult carrying out the implementation						

Section B

Please use the scale below to answer the following questions below by marking **X**. the rating scale 1 - 5 represent the frequency of occurrence;

1 - Never; 2 – Very Rare, 3 –Seldom,4 – Frequent, 5 - Very Frequent

1	**What were the main barriers faced by the company during the implementation**						
		1	**2**	**3**	**4**	**5**	
a	Supervision / quality control						
b	Fluctuations and variations						
c	Subcontractor’s involvement						
d	Resistance to change						
e	Cultural issues						
f	Lengthy approval procedure by client						

Section C

Please use the scale below to answer the following questions below by marking **X**. the rating scale 1 - 5 represent the frequency of occurrence;

1 – strongly disagree; 2 – disagree; 3 – neither agree or disagree; 4 – agree; 5 – strongly agree

1	**Which of the following will you identify as the critical success factors for this implementation**						
		1	**2**	**3**	**4**	**5**	
a	Training and empowering last planners						
b	Involvement of all stakeholders (team work)						
c	Motivating people to make changes						
d	Having the appropriate human capital						
e	Top management support						
f	Manage resistance to change						
g	Close relations with suppliers						

Section D

Please use the scale below to answer the following questions below by marking **X**. the rating scale 1 - 5 represent the frequency of occurrence;

1 – strongly disagree; 2 – disagree; 3 – neither agree or disagree; 4 – agree; 5 – strongly agree

1	**From your experience in your work field, what benefits have been gained from implementing LPS in this project?**						
		1	2	3	4	5	**total**
a	Identifying & addressing potential problems before they become obstacles in the project						
b	Reducing the incidence of bad news & to get what bad news there is early						
c	Developing supervisory skills and reducing the load on management						
d	Creating a more predictable & reliable production program						
e	Delivering projects more safely, faster & at reduced cost						
f	Stabilises projects & support other lean actions						
g	Improving construction logistics on projects						
h	Improving predictions of labour required						
i	Reduces the risk of catastrophic loss						
j	Completes projects on schedule						

THANK YOU FOR YOUR TIME!

APPENDIX 3B - QUESTIONNAIRE FOR CASE STUDY 2

Section A

Please use the scale below to answer the following questions below by marking **X**. the rating scale 1 - 5 represent the frequency of occurrence;

1 – strongly disagree; 2 – disagree; 3 – neither agree or disagree; 4 – agree; 5 – strongly agree

		1	**2**	**3**	**4**	**5**	
1	LPS was very effective within this project						
2	The results achieved from the implementation are they satisfactory from your previous projects						
3	The Weekly Work Plans & PPC were very useful						
4	It was difficult carrying out the implementation						

Section B

Please use the scale below to answer the following questions below by marking **X**. the rating scale 1 - 5 represent the frequency of occurrence;

1 - Never; 2 – Very Rare, 3 –Seldom,4 – Frequent, 5 - Very Frequent

1	**What were the main barriers faced by the company during the implementation**						
		1	**2**	**3**	**4**	**5**	
a	Supervision / quality control						
b	Fluctuations and variations						
c	Subcontractor's involvement						
d	Resistance to change						
e	Cultural issues						
f	Lengthy approval procedure by client						

Section C

Please use the scale below to answer the following questions below by marking **X**. the rating scale 1 - 5 represent the frequency of occurrence;

1 – strongly disagree; 2 – disagree; 3 – neither agree or disagree; 4 – agree; 5 – strongly agree

1	**Which of the following will you identify as the critical success factors for this implementation**						
		1	**2**	**3**	**4**	**5**	
a	Training and empowering last planners						
b	Involvement of all stakeholders (team work)						
c	Motivating people to make changes						
d	Having the appropriate human capital						
e	Top management support						
f	Manage resistance to change						
g	Close relations with suppliers						

Section D

Please use the scale below to answer the following questions below by marking **X**. the rating scale 1 - 5 represent the frequency of occurrence;

1 – strongly disagree; 2 – disagree; 3 – neither agree or disagree; 4 – agree; 5 – strongly agree

1	**From your experience in your work field, what benefits have been gained from implementing LPS in this project?**						
		1	2	3	4	5	**total**
a	Identifying & addressing potential problems before they become obstacles in the project						
b	Reducing the incidence of bad news & to get what bad news there is early						
c	Developing supervisory skills and reducing the load on management						
d	Creating a more predictable & reliable production program						
e	Delivering projects more safely, faster & at reduced cost						
f	Stabilises projects & support other lean actions						
g	Improving construction logistics on projects						
h	Improving predictions of labour required						
i	Reduces the risk of catastrophic loss						
j	Completes projects on schedule						

THANK YOU FOR YOUR TIME!

APPENDIX 3C - RESPONSE TO QUESTIONNAIRE FOR CASE STUDY I

Section A.

Please use the scale below to answer the following questions below by marking **X**. the rating scale 1 - 5 represent the frequency of occurrence;

1 – strongly disagree; 2 – disagree; 3 – neither agree or disagree; 4 – agree; 5 – strongly agree

		1	**2**	**3**	**4**	**5**	**total**
1	LPS was very effective within this project	0	0	6	21	7	34
2	The results achieved from the implementation are they satisfactory from your previous projects	0	0	0	24	10	34
3	The Weekly Work Plans & PPC were very useful	0	1	8	18	8	34
4	It was difficult carrying out the implementation	9	12	4	9	0	34

Section B

Please use the scale below to answer the following questions below by marking **X**. the rating scale 1 - 5 represent the frequency of occurrence;

1 - Never; 2 – Very Rare, 3 –Seldom,4 – Frequent, 5 - Very Frequent

1	**What were the main barriers faced by the company during the implementation**						
		1	**2**	**3**	**4**	**5**	**total**
a	Supervision / quality control	3	7	11	12	1	34
b	Fluctuations and variations	0	4	8	21	1	34
c	Subcontractor's involvement	0	7	5	20	2	34
d	Resistance to change	0	0	1	30	3	34
e	Cultural issues	0	2	4	21	7	34
f	Lengthy approval procedure by client	2	1	11	14	6	34

Section C

Please use the scale below to answer the following questions below by marking **X**. the rating scale 1 - 5 represent the frequency of occurrence;

1 – strongly disagree; 2 – disagree; 3 – neither agree or disagree; 4 – agree; 5 – strongly agree

1	**Which of the following will you identify as the critical success factors for this implementation**						
		1	**2**	**3**	**4**	**5**	**total**
a	Training and empowering last planners	0	0	0	30	4	34
b	Involvement of all stakeholders (team work)	0	2	11	17	4	34
c	Motivating people to make changes	0	0	1	30	3	34
d	Having the appropriate human capital	0	7	20	5	2	34
e	Top management support	0	0	0	15	19	34
f	Manage resistance to change	0	2	12	10	10	34
g	Close relations with suppliers	0	1	9	20	4	34

Section D

Please use the scale below to answer the following questions below by marking **X**. the rating scale 1 - 5 represent the frequency of occurrence;

1 – strongly disagree; 2 – disagree; 3 – neither agree or disagree; 4 – agree; 5 – strongly agree

1	**From your experience in your work field, what benefits have been gained from implementing LPS in this project?**						
		1	2	3	4	5	**total**
a	Identifying & addressing potential problems before they become obstacles in the project	0	0	2	25	7	34
b	Reducing the incidence of bad news & to get what bad news there is early	0	0	5	20	9	34
c	Developing supervisory skills and reducing the load on management	0	8	11	8	7	34
d	Creating a more predictable & reliable production program	1	4	13	9	7	34
e	Delivering projects more safely, faster & at reduced cost	0	8	5	16	5	34
f	Stabilises projects & support other lean actions	0	0	11	16	7	34
g	Improving construction logistics on projects	1	0	5	23	5	34
h	Improving predictions of labour required	1	1	13	9	10	34
i	Reduces the risk of catastrophic loss	0	3	13	10	8	34
j	Completes projects on schedule	0	0	0	27	7	34

APPENDIX 3D - RESPONSE TO QUESTIONNAIRE FOR CASE STUDY 2

Section A.

Please use the scale below to answer the following questions below by marking **X**. the rating scale 1 - 5 represent the frequency of occurrence;

1 – strongly disagree; 2 – disagree; 3 – neither agree or disagree; 4 – agree; 5 – strongly agree

		1	**2**	**3**	**4**	**5**	**total**
1	LPS was very effective within this project	0	0	6	21	7	34
2	The results achieved from the implementation are they satisfactory from your previous projects	0	0	0	24	10	34
3	The Weekly Work Plans & PPC were very useful	0	1	8	18	8	34
4	It was difficult carrying out the implementation	9	12	4	9	0	34

Section B

Please use the scale below to answer the following questions below by marking **X**. the rating scale 1 - 5 represent the frequency of occurrence;

1 - Never; 2 – Very Rare, 3 –Seldom,4 – Frequent, 5 - Very Frequent

1	**What were the main barriers faced by the company during the implementation**						
		1	**2**	**3**	**4**	**5**	**total**
a	Supervision / quality control	3	7	11	12	1	34
b	Fluctuations and variations	0	4	8	21	1	34
c	Subcontractor's involvement	0	7	5	20	2	34
d	Resistance to change	0	0	1	30	3	34
e	Cultural issues	0	2	4	21	7	34
f	Lengthy approval procedure by client	2	1	11	14	6	34

Section C

Please use the scale below to answer the following questions below by marking **X**. the rating scale 1 - 5 represent the frequency of occurrence;

1 – strongly disagree; 2 – disagree; 3 – neither agree or disagree; 4 – agree; 5 – strongly agree

1	**Which of the following will you identify as the critical success factors for this implementation**						
		1	**2**	**3**	**4**	**5**	**total**
a	Training and empowering last planners	0	0	0	30	4	34
b	Involvement of all stakeholders (team work)	0	2	11	17	4	34
c	Motivating people to make changes	0	0	1	30	3	34
d	Having the appropriate human capital	0	7	20	5	2	34
e	Top management support	0	0	0	15	19	34
f	Manage resistance to change	0	2	12	10	10	34
g	Close relations with suppliers	0	1	9	20	4	34

Section D

Please use the scale below to answer the following questions below by marking **X**. the rating scale 1 - 5 represent the frequency of occurrence;

1 – strongly disagree; 2 – disagree; 3 – neither agree or disagree; 4 – agree; 5 – strongly agree

1	**From your experience in your work field, what benefits have been gained from implementing LPS in this project?**						
		1	2	3	4	5	**total**
a	Identifying & addressing potential problems before they become obstacles in the project	0	0	2	25	7	34
b	Reducing the incidence of bad news & to get what bad news there is early	0	0	5	20	9	34
c	Developing supervisory skills and reducing the load on management	0	8	11	8	7	34
d	Creating a more predictable & reliable production program	1	4	13	9	7	34
e	Delivering projects more safely, faster & at reduced cost	0	8	5	16	5	34
f	StabiliSes projects & support other lean actions	0	0	11	16	7	34
g	Improving construction logistics on projects	1	0	5	23	5	34
h	Improving predictions of labour required	1	1	13	9	10	34
i	Reduces the risk of catastrophic loss	0	3	13	10	8	34
j	Completes projects on schedule	0	0	0	27	7	34

APPENDIX 4 – Interview for Case study 3

Section A- ***Introduction***

9. **What is your current designation within your organisation?**
10. **How long you have worked in the construction industry?**
11. **How long have you been with the organisation?**
12. **What is the type and size of the projects your organisation mostly engages in?**

Section B- ***Project management Practice***

29. **What conventional project management system is in place within this orgainsation?**
30. **Are you familiar with the concept of Lean Construction and its tools?**
31. **Describe how projects were planned and controlled using the project management approach**
32. **What criteria do you use in judging a successful project?**
33. **How did planning and scheduling of site work occur? And who plans and coordinates the program or schedule at the site?**
34. **Who are key players/ participants involved in the planning and control process of your organisation?**
35. **Describe logistics at the site. How is labour, material and plants coordinated at site?**
36. **How often do you have planning and site meetings during construction processes?**
37. **What were possible challenges to the project and how were they overcome?**
38. **What kind of communication tools do you use during the construction process, i.e. Communication gadgets and tools used on site?**

APPENDIX 5A - QUESTIONNAIRE FOR CASE STUDY 3

Profile of respondent

Please mark X only on one box for Q1 – Q3 e.g. **X**

1 **Which of the following bests describes your profession**

Architect ☐ | Civil Engineer ☐ | Surveyor ☐ | other ☐

2 **What level of experience (in years) do you have in construction**

0 - 4 ☐ | 5 - 10 ☐ | 11 - 15 ☐ | Over 15 ☐

3 **Which of the following best describes your current position in the company**

Top level manager ☐ | Project manager ☐ | Site manager ☐ | Site supervisor ☐

Project engineer ☐ | Foreman ☐ | others ☐

Profile of organisation

Please mark X in applicable areas. (More than one choice can be picked)

1 **Which of the following best describes your companies areas of operation**

Commercial and residential buildings ☐ | Highway and transportation ☐

Engineering construction ☐ | Marine and shore works ☐

Industrial facilities ☐ | Infrastructural facilities ☐

Others ☐ | Please specify:

Please mark X only on one box for Q2 – Q3 e.g. **X**

2 **Please indicate the average number of employees**

10 - 50 ☐ | 51 - 100 ☐ | 101 -150 ☐ | 151-250 ☐ | Above 250 ☐

3 **Please indicate the average value of projects your company is usually engaged in**

Less than 10 Million Naira ☐ | 10 – 100 Million Naira ☐ | 101 – 500 million Naira ☐

More than 500 million Naira ☐

Question number	PERFORMANCE OF THE PROJECT	Strongly disagree	Disagree	Neither agree/ disagree	Agree	Strongly agree
		1	2	3	4	5
Q1	In terms of good leader skills, did the workforce have easy and direct access to the site management					
Q2	Within the project, was there collaboration between site operatives?					
Q3	Was there an open and free communication within the project?					
Q4	Within the project, was there an effective Health and safety system in place for the workforce and public					
Q5	Did the project organisation in place allow and encourage site operatives to be creative and try out new things					
Q6	Did the site managers track the performance of the project by using regular project management approaches					
Q7	Within the project, did the site management recognise the performance of the workers on site					
Q8	Was training and staff development provided for site workers					

Question number	PERFORMANCE OF THE PROJECT	Very dissatisfied	dissatisfied	Neither agree/ dissatisfied	Satisfied	Very satisfied
		1	2	3	4	5
Q1	Please kindly rate the level of innovation experienced on this project					
Q2	Please kindly rate the level of organisational commitment, care and concern to all workers on the site					
Q3	How satisfied are the operatives with the wages on site					
Q4	How satisfied are project operatives with the welfare facilities and site conditions in place.					

APPENDIX 5B - RESPONSE TO QUESTIONNAIRE FOR CASE 3

Question number	DESCRIPTION OF THE QUESTION	Strongly disagree	Disagree	Neither agree/ disagree	Agree	Strongly agree	TOTAL
		1	2	3	4	5	
Q1	In terms of good leader skills, did the workforce have easy and direct access to the site management	0	0	0	10	20	30
Q2	Within the project, was there collaboration between site operatives?	0	0	0	18	12	30
Q3	Was there an open and free communication within the project?	0	0	0	9	21	30
Q4	Within the project, was there an effective Health and safety system in place for the workforce and public	0	3	6	19	2	30
Q5	Did the project organization in place allow and encourage site operatives to be creative and try out new things	0	0	4	18	8	30
Q6	Did the site managers track the performance of the project by using regular project management approaches	0	0	2	18	10	30
Q7	Within the project, did the site management recognise the performance of the workers on site	0	0	0	19	11	30
Q8	Was training and staff development provided for site workers	1	11	7	7	4	30

Question number	DESCRIPTION OF THE QUESTION	Very dissatisfied	dissatisfied	Neither agree/ dissatisfied	Satisfied	Very satisfied	TOTAL
		1	2	3	4	5	
Q1	Please kindly rate the level of innovation experienced on this project	0	0	0	3	27	30
Q2	Please kindly rate the level of organizational commitment, care and concern to all workers on the site	0	2	1	13	14	30
Q3	How satisfied are the operatives with the wages on site	2	8	3	10	7	30
Q4	How satisfied are project operatives with the welfare facilities and site conditions in place.	3	7	6	8	6	30

APPENDIX 6A - Look ahead charts

LOOK AHEAD SCHEDULE																											
	Project																										
	Nature of job																										
	Planner																										
	Checked by																										
	Prep by																										
		Week ending (___/___/___)						*Week ending* (___/___/___)						*Week ending* (___/___/___)						*Week ending* (___/___/___)							OUTSTANDING NEEDS
Activities		m	t	w	t	f	s	m	t	w	t	f	s	m	t	w	t	f	s	m	t	w	t	f	s		

APPENDIX 6B - Constraint analysis charts

CONSTRAINTS ANALYSIS

ID	Activities	WEEK __/__/__	contract	designs	**Submittals & documentati**	operations	equipments	Labour	weather	materials	others

APPENDIX 6C – Weekly Work Plan Charts

Project..... Week Commencing.....

Stage..... Prepared by.....

Date.....

Ref	**Task** *Criteria for release of assignments: Defined, sound, ordered, sized*	**Final Make Ready needs** *Work that must and can be performed prior to release of work*	Who will do the work	Mon	Tue	Wed	Thurs	Fri	Sat	Sun

APPENDIX 6D - Observation charts

PPC Charts

Ref	**Task ID**	Week :	Completed planned tasks	
		Planned Activities (tasks)	yes	no

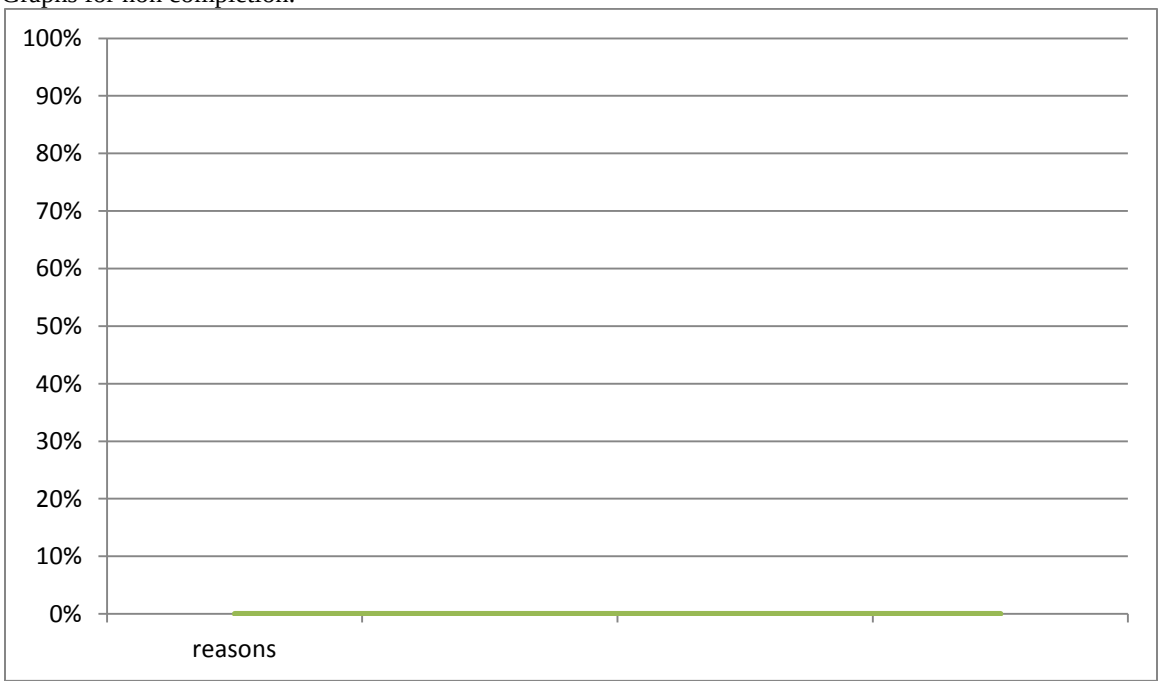
$$\text{PPC} = \frac{number\ of\ completed\ activities}{total\ number\ of\ activities} \text{ X } 100\%$$

APPENDIX 6E - Reason for incomplete assignment charts

PPC & REASONS DATA

Week	(__/__/__)	(__/__/__)	(__/__/__)	(__/__/__)	(__/__/__)	
PPC (%)						
Tasks Completed						
Tasks planned						
Reasons						total
contract						
designs						
Submittals and documentation						
operations						
equipments						
labour						
weather						
materials						
others						

Graphs for non completion:



APPENDIX 7 – CONSENT LETTER TO PARTICIPATE IN FOCUS GROUP

Faculty of Science and Engineering
Dean:
Prof. Nduka Ekere BENG MSc PhD CEng FIET

Faculty of Science and Engineering
University of Wolverhampton
Technology Centre
MI Building
City Campus South
Wulfruna Street
Wolverhampton WV1 1lY
United Kingdom

T. +44 (0)1902 321000
F. +44 (0)1902 321478
W. www.wlv.uk/stech

Dear Sir,

REQUEST TO PARTICIPATE IN A FOCUS GROUP SESSION

I am a PhD student at the University of Wolverhampton, United Kingdom, currently conducting research on improving construction processes in Nigeria using the Last Planner System (LPS). The Last Planner System has been implemented on two case projects in Nigeria, and the challenges that occurred during the implementation have been identified.

A framework has been proposed in this research, to overcome the challenges of implementing LPS in Nigeria. It is thought that the framework would be a useful resource to the construction industry, and other stakeholders, particularly for enhancing the implementation of LPS within the Nigerian construction industry.

In view of this, I would be very grateful if you could please participate in a Focus Group session taking place at Dayspring Hotel, Wuse zone 6, Abuja on Saturday 7th December 2013 by 11am for the validation of the framework proposed in this research. All the data gathered from this focus group session would be STRICTLY CONFIDENTIAL and used for research purposes only. I would like to thank you in advance for your valued and kind consideration.

If you would like to receive further information about the research, please feel free to contact me or other members of the research team; the team is made up of Dr. David Oloke, Dr. Subashini Suresh and Prof. Jamal Khatib all from the University of Wolverhampton, UK. I can be reached anytime via my email [e-mail address redacted] or my cell phone [number redacted].

I will be very grateful if you will be willing to participate in this research.

Yours sincerely

Ograbe Ahiakwo
(PhD Researcher)
University of Wolverhampton, UK.

Please write your name and sign below and check yes or no, If you want to take part of this focus group.

_____

NAME & SIGNATURE

_____ *Yes, I would like to take part in the focus group.*

_____ *No, I would not like to participate in the focus group.*