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Evaluating the Application of Lean Principles to Improve Project Performance at Eskom KZNOU

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DECLARATION

This thesis is a presentation of my original research work. Wherever contributions of others are involved, every effort is made to indicate this clearly, with due reference to the literature, and acknowledgement of collaborative research and discussions.

The work was done under the guidance of Dr Elias Munapo, at the Graduate School of Business, UKZN, Durban.

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Abstract

Eskom's financial sustainability is at risk which makes their project delivery model all the more important. At present there are numerous challenges and problems facing Eskom, especially with project performance at the KwaZulu-Natal (KZN) Operating Unit. The leading yardstick for success of any project is to deliver the project within cost and time parameters. Lean project management is a new management practice that has been successfully implemented in many companies and industries with remarkable success. The purpose of this study is to evaluate the applicability of lean principles with the aim of increasing the likelihood of project success within the ambit of project management principles. This study investigates the applicability of implementing lean principles effectively in the project environment of Eskom. Firstly, the study examines the current understanding of project management as executed in Eskom. Secondly, the research assessed the appreciation of lean principles through a survey that was conducted at the company. The research revealed that 83% of the respondents were not aware of lean technologies; however 94% of them agreed that lean principles can be used to improve project delivery and performance. The survey presented some of the lean tools that have been used effectively in the execution of projects, which include continuous improvement, reduction in variability, work standardisation, housekeeping and being customer centered. The research highlighted that some of the lean principles are not being fully implemented; and they need to be improved in order to increase project performance. Simultaneously, some of the lean principles are being implemented within the current project management processes; however the principles need to be reviewed and improved upon. In light of the challenging times in which Eskom finds itself, it would be prudent to consider implementing lean principles within the project management environment. It is recommended that Eskom review their current project management principles to include lean principles in the execution of projects. The application of lean principles would definitely assist in eliminating wasteful processes in the project activities and will contribute in projects being completed on time and within budget.

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List of Abbreviations

Just in Time	JIT
KwaZulu Natal Operating Unit	KZNOU
Last Planner System	LPS
Lean Benefits Realisation Management	LBRS
Lean Construction Institute	LCI
Project Management Book of Knowledge	PMBOK
Total Quality Management	TQM
Toyota Production System	TPS
Value Stream Mapping	VSM
Work Breakdown Structure	WBS

CHAPTER I

INTRODUCTION TO THE RESEARCH

1.1 Introduction and Background

In the twenty first century project management has emerged as the prevailing way of conducting various business activities and as such, businesses have become obligated to finding innovative ways of delivering services and products. Moreover, customers are demanding more complex products and services, which require diverse skills, which should be accomplished within leaner organisations with stringent budgets whilst maintaining superior quality echelons. Some management principles of the past can no longer support these requirements and the trepidations of project delivery, which include "delayed projects, projects over budget and projects completed unsatisfactorily in terms of quality and customer satisfaction" are very real concerns (Tonnquist, 2008). These factors are the primary contributors to many businesses seeking new methods for delivering projects on time, within cost and budget, be they on a large scale or small scale.

Projects are renowned for being over the allocated budget, or laden with scope creep or, delivered outside the negotiated time. Many of these aforementioned hurdles have been expansively reviewed in the literature, and whilst the conventional project management approach has been useful in managing some of the complications, projects frequently fail. Project management is described as the planning of a project by allocating the appropriate resources to finish the project on time, on budget and within certain quality guidelines. Figure 1.1 shows the "Triple Constraint Triangle" which depicts the relationship between the project management principles as all projects are executed within these three constraints. Time represents the available time to complete the project, cost indicates the available funding and quality specifies the standards to which the project must be carried out in order to be deemed a success.

Figure 1.1 Trade-offs of time, cost and quality (Source: adapted from Bell and Orzen, 2011)

1.2 The Triple Constraint Model in Project Management

Project driven organizations' main objective is to deliver the project as per the project scope mandate and whilst the objectives are justified, these project-based organisations miss the opportunities for business improvement and greater success (Ballard & Howell, 2003). Focus on project deliverables sometimes does not allow for improvement in processes, which are equally important. Project management focuses on the triple constraint concept, which implies that all projects are confined to the elements of time, cost and scope (Kerzner, 2013).

It is very possible to deliver a project within the allocated time and at the right quality, however costs will be compromised. If a project's budget is decreased then this will compromise the scope thus forcing the project manager to reduce the scope to be within the new budget. Likewise, if the project sponsor increases the scope of the project, then this is likely to influence the project budget and the time. It is therefore evident that one cannot change a single element within the triple constraint triangle without affecting another element within the triangle.

Project management is not merely a process but an art, as the project manager will need to find the balance between these three elements to meet the demands of the organisation. Therefore, the project manager should identify the key driver for the project and suitably adjust the other elements. Project managers normally manage the tradeoff between the three principles, by fixing one principle and varying the other two in inverse relation to each other. Normally the project manager may fix the time element, thus inferring that the quality of the

project will largely be dependent on the available funds. Similarly, if the project manager has fixed the quality element then the project cost will depend on the available time, that is, if the project manager has more time, he can complete the project with fewer resources.

In theory the above tradeoff between time, cost and quality works, however studies indicate that project managers need to tradeoff one element and fix the other two elements, and more often than not time and cost are fixed which will affect the quality and the project scope. This phenomenon is known as scope creep, is associated with the triple constraint triangle, and is almost inescapable forcing new functionality onto the project. This means that the project manager needs to constantly juggle the three elements to ensure an effective tradeoff between time, cost and quality (Kerzner, 2013).

This has lead the researcher to investigate the lean way of delivering projects which had its origins at the Toyota Motor Company in Japan. Since then the lean principles have progressed from geographic and economic constraints, from top-down, management-led innovation and from bottom-up pragmatic problem solving (Ballard, 2000). The application of lean ideologies to business practices has been effective in optimizing productivity, improving quality whilst reducing lead times and increasing the flexibility in processes as well as huge cost savings. The past decade has shown remarkable success and improved quality in the construction and manufacturing industries by applying the philosophies of lean.

The research will embark from the following platform of lean: "*Lean construction is the continuous process of eliminating waste, meeting or exceeding all customer requirements, focusing on the entire value stream and pursuing perfection in the execution of a constructed project"* (Ballard, 2000). The study will explore the applicability of the lean principles in a project and how these lean theories can significantly improve project delivery at Eskom's KZNOU (Operating Unit).

1.3 Conventional Project Management versus Lean Methods

The lean methodology is an innovative method of project management in the construction industry. There are more than a few variations between the lean approach and the conventional project management approach. Listed below are some of these differences as discussed in the literature (Sicat, 2012):

- The role of control in lean is to assure reliable workflow in contrary to conventional method, which takes corrective actions after detecting variances.
- The main target of the lean approach is to maximize value by improving the whole process but in the conventional method optimization is for each activity separately.
- Lean is a pull-driven approach while conventional method is push-driven approach.
- Reducing variations at early stages is one of the main aims of lean thinking while in the conventional approach it is not considered.

1.4 Brief Background on Lean Approach

Lean was first introduced by Japanese manufacturers, in particular at the Toyota Motor Corporation and became known as the Toyota Production System (TPS). TPS was initially introduced by Japan after World War II when Japan required producing small batches of cars in many varieties contrary to the Ford principle of mass production which was the same cars with large production runs (Conte 2002). Toyota resolved that the theory of mass-producing cars was no longer efficient, especially, after the decline in sales. Hence, they initiated new thinking and introduced the Toyota Production system, also called lean production (Ahrens 2006). Toyota's main resolve in launching this new idea was to boost production efficiencies by manufacturing high quality products with maximum value and at a low cost (Jacobs 2010). The system was based on achieving a continuous production flow in order to reduce inventories and by eliminating non-value adding activities. In lean systems, the lean techniques allow for continuous identification and removal of waste from the entire process (Badurdeen 2006). Lean systems aspire to meet customer requirements by delivering the product quickly and with no intermediary issues (Howell & Lichtig, 2008). The manufacturing process has seen noticeable improvements and development after applying lean production principles to the industry (Zimmer 2005).

1.5 From Lean Manufacturing to Lean Project Management

The construction processes related to projects are becoming more multifaceted and therefore a more rational approach is required that will solve the chronic difficulties associated with projects. Lean Construction was introduced by The Lean Construction Institute, and described as a production management based approached to project deliver a new way to design and build capital facilities (Blakely, 2008). The main purpose of lean system is to maximize value and minimize waste by using the appropriate lean techniques (O' Salem, et

al. 2006). Despite the significant differences between the features of construction of projects and manufacturing, they almost share the same goals and pursue the same principles such as system optimization through collaboration, continuous improvement, focus on customer satisfaction, workflow by eliminating obstacles and creating pull production.

Implementing lean philosophy to projects presents challenges due to the significant differences in the physical characteristics of the end product of manufacturing and end product of a project. One-of-a-kind production, site production and complexity are some of the features that distinguish manufacturing from projects (O' Salem, et al. 2006). These distinguishing features are described below:

i. **One of a kind production**: The frequency of customizing projects is higher than in manufacturing where the customers play an important role in customization or change throughout the life cycle of the project. Contrary to projects, manufacturing plants are known for using specialized equipment to standardize the items accepting very low level of customizations by retailers (O' Salem, et al. 2006; Koskela, 1992);
ii. **Site-production**: Construction of projects happens on site where the production process, which is the installation and erection, is carried out at the final project site. Also, the contractor must assure high-quality standards for the erected components on site which is mostly affected by site conditions, thus impacting the quality of the product (O' Salem, et al. 2006; Koskela, 1992);
iii. **Complexity**: Project construction process is complicated, unique and dynamic where each project is a new task accompanied by different resources, ideas and initial design with variable specifications. In manufacturing, the production process is optimized by using specialized facilities with appropriate technology to ensure the reliable flow of the product (O' Salem, et al. 2006).

These characteristics together cause many uncertainties in the production process. The climatic and soil conditions, coordination between different trades and the customer changes are some of the uncertainties that may encounter any project causing significant impact on the time and cost of the project (O' Salem, et al. 2006). Despite the differences between projects and manufacturing, they are both aiming to deliver a competitive product in the shortest time possible with maximum value and quality and at less cost (Zimmer 2005). Given the aforementioned resemblances, then the applicability of lean principles was considered in projects.

1.6 Applicability of Lean Principles in Project Management

Lean project management focuses on reducing overall elapsed project time to break through the seemingly inherent trade-off of time, cost, and scope. As waste is removed from both business processes and project management methods, the impact of the triple constraints is diminished (Bell & Orzen, 2011). Lean principles focus on the eradication of waste by the use of visual techniques (Pepper & Tedding, 2011); whilst project management incorporates the use of project tools and techniques with the aim of meeting project obligations within the five process groups as depicted in the Project Management Book of Knowledge (PMBOK) (2013). The lean methodology could be applied to projects by reducing the overall lost time and costs on projects and by finding a symmetry between the three constraints. Lean methodology applies improvements to business processes and is applicable to project management methodology; by merely removing non-value adding processes, the consequence of time, cost and scope can be minimised.

1.8 A Brief Outline of Eskom

Eskom Holdings Limited is a household name in South Africa, and has a long and influential history in the country, and on the African continent. The company was established in 1923 as the Electricity Supply Commission 'ESCOM'. This state-owned utility is responsible for generating, transmitting and distributing electricity to industrial, mining, commercial, agricultural and residential customers. In essence, Eskom has the monopoly in the electricity sector, which also places a tremendous amount of responsibility in the utility's hands (Koen, 2012). Eskom is a focal contributor in the governance of electricity and operates within a framework that is subjugated by the needs of mining sectors and other large industries.

All projects in Eskom's KZNOU conform to the approved standard Eskom project life cycle model in order to govern and standardise the project management process that was derived from the PMBOK. There are namely three project processes at Eskom, which are (http://intranet.eskom.co.za):

- **Independent projects**: - these projects are ones that can stand alone and be completed on their own and achieve their objective as stated in the executive summary of the project. Independent projects follow the KZNOU project life cycle model.

- **Dependent projects**: - these projects are projects that have a one-way dependency on another. Project A can be completed without Project B being completed and still achieve the objective stated in the executive summary of the project. Project B can be completed on its own, but it will, however, not achieve its objective as stated in the executive summary.
- **Interdependent projects**: - these projects cannot be initiated separately, as they will not achieve the objective as stated in the executive summary of the project. If any one of these is stopped or not completed, the rest of the projects cannot realise their stated objective.

1.9 Rationale of the Study

The rationale of a study is to present the statement of how the researcher developed an interest for the topic and why the researcher wants to conduct this study (Maree, 2009). The rationale of this research was to investigate the likelihood of applying lean principles in the project management environment with the intention of improving project delivery within time, cost, scope and quality standards, specifically to Eskom's KZNOU (Operating Unit). Eskom has been rolling out a multitude of small to complex projects ranging from a capital budget of R5m to R50m per project and over a period of five years, no single project was completed either in terms of cost, quality or time. In addition to this Eskom is facing extremely challenging times with respect to financing of projects. Due to the lack of bulk infrastructure networks, Eskom embarked on a capital expansion programme with the aim of delivering power stations that would sustain existing and future growth. Unfortunately, the projected costs for the power stations were under-estimated, catapulting Eskom's finance into a downward trend. This in turn affected the major projects as Eskom had difficulty financing a multitude of smaller projects. Projects were started but could not be completed as the scope had to be reduced in order to reduce expenditure. Reviewing the five-year period from 2011 until 2015 there is ample evidence that Eskom is in need of reviewing their project delivery processes with the aim of removing wasteful activities. Hence, the researcher has decided to embark on this research with the aim of identifying whether or not the current project process is still applicable, or should the process be refined using lean principles or does Eskom need to re-engineer the entire process?

1.10 Problem Statement

The problem statement was formulated after conducting initial research in the processes used for constructing projects as well as discussions that were held with senior executives of Eskom. In addition to this the researcher has more than 15 years of project experience and could easily identify flaws in the current process of executing projects. Together with the researcher's experience and the discussions with the executives it was highlighted that there is lack of awareness of lean principles in the construction and delivery of projects at Eskom.

Eskom is under immense socio-economic and political pressure to deliver electrification projects more efficiently at a suitable cost within the expected time. The current processes are challenged to keep up with the service delivery demands therefore alternative approaches to deliver projects more cost effectively are being investigated. Eskom is facing many problems such as delays in executing projects, over budgeting and poor quality. The conventional project management method is not appropriate to deliver a multitude of projects due to inadequacies in the existing approach as illustrated in the literature review chapter (Koskela & Howell, 2002). The project management monitoring and control processes as depicted in the PMBOK (2013) convey a reactive approach rather than proactive approach, indicating that actions are only taken after the problem has emerged.

The Lean approach is still not widely applied in project management organisations. The emphasis within the Lean approach has mainly been focused on data collected from resources within Eskom. Limited studies on lean construction were conducted in Eskom concerning the applicability of the lean principles in construction of projects.

Figure 1.2 illustrates a graphical view of planned expenditure versus actual expenditure over a 5-year period. It is visible that Eskom has not been delivering projects as per the plan. Figure 1.3 provides a view of the number of planned projects versus the number of completed projects. It is apparent that projects are planned, however they are not being completed within the time, cost and quality constraints. The conventional project management processes are proving to be more reactive in nature causing the project managers to make decisions after the problem has occurred. The aim of this study is to analyse the extent to which the conventional project management principles are not working and to investigate the applicability of lean principles in a project environment.

Figure 1.2 Five-year capital expenditure on planned and completed projects (Source: http://intranet.eskom.co.za/CommunicationsContentHub/Pages, 2011 until 2015)

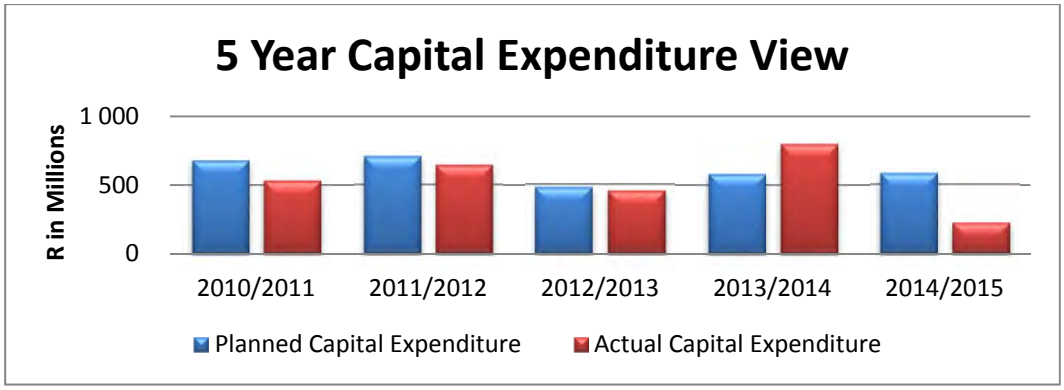
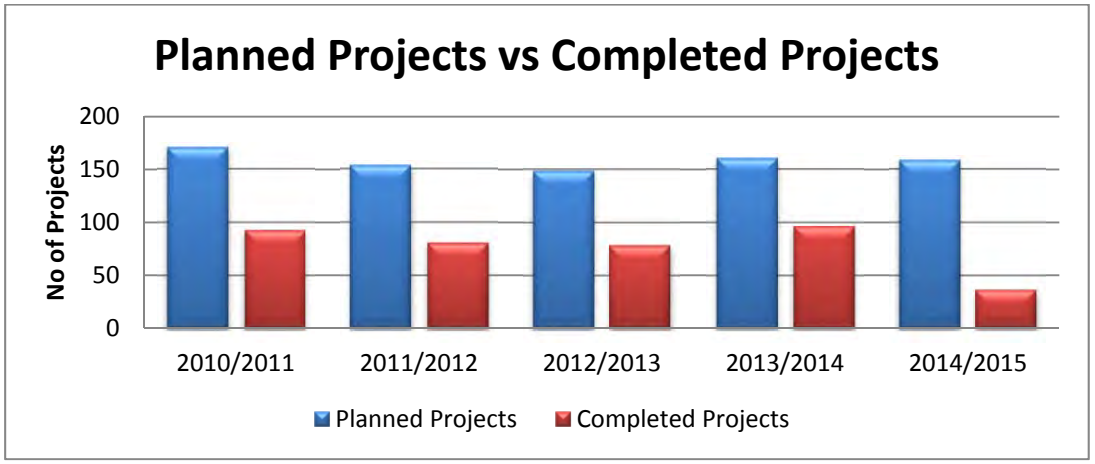


Figure 1.3 Five-year view on the number of projects planned and completed (Source: http://intranet.eskom.co.za/CommunicationsContentHub/Pages, 2011 until 2015)



Lean principles are widely applied to manufacturing concerns and have only recently been introduced to project management. For this reason, the research focused the principles of lean. The research concentrated on the conventional project management process as outlined by the PMBOK as implemented by Eskom. Based on this, the difference between the conventional project management principles and lean principles were addressed to show the shortcomings of the conventional principles as compared to lean application methodologies.

1.11 Research Questions

The following research questions were intended to explain the main issues that affect project delivery and consequently guide the researcher to focus on the research problem.

The following questions were considered for this study:

- How effective are the conventional project management processes?
- Can lean processes be implemented in the current processes?
- Are there activities or processes that are wasteful?

1.12 Research Objectives

The main objective of the study is to improve project delivery by investigating the effectiveness of the existing project process and the applicability of lean principles to deliver projects on time and on budget. Therefore, the researcher will be concentrating the research around the following:

- To investigate the effectiveness of the conventional project management processes.
- To identify the areas in the current project management processes to apply lean principles.
- To identify non-value adding processes/activities within the existing process.

1.13 Significance of the Research

The lean methodology is a fairly new approach in project management as previous research is limited to construction and manufacturing industries only. Research also indicates that projects are seldom completed within the elements of time, cost, scope and quality. A change in one constraint has an impact on the other principles of the project. Thus in piloting this study in a project management environment, Eskom could benefit by magnifying their understanding of the factors that could influence the project model and deliver projects within the triple constraints.

It is very likely that Eskom will gain novel insight into dynamics that could power the company into the future, which is a lean project delivery company thriving in the South African service industry.

1.14 Limitations of the Study

The lean methodology is a widespread subject and due to the confines of time and resources it is not possible to evaluate all concepts of lean, thus this research will be limited to the principles of lean. Secondly there are not many projects that are executed on the foundations of lean thus the study will be conjectural. Thirdly, the research will be based on limitations of

a general questionnaire. Lastly, this research will be limited to the employees of Eskom, specifically the employees who work in the electrification project management department and will include all levels of employees.

1.15 Proposed Layout of the Study

This study consists of five chapters.

The study will start with *Chapter one* which has been covered above.

This is followed by *Chapter two* which alludes to various literature on lean philosophies; by providing insights into the evolution of lean, present views on lean construction and lean principles. This chapter will also make reference to project management; by providing the history of project management and makes reference to the triple constraint model according to the Project Management Book of Knowledge. The literature review makes reference to the relation of lean methodology and the key factors affecting project performance and delivery to projects executed at Eskom.

Chapter three is based on research methodology and exhibits the analysis on the questionnaire as conducted in Eskom KZN Operating Unit.

Chapter four provides the findings of the empirical data.

Chapter five provides recommendations, conclusions and areas of future research.

1.17 Concluding Remarks

This chapter outlined the research problem and the rationale for conducting the study as well as discussing the key problems, terms and concepts. The next chapter is the literature review, which provides an academic view of the preferred research as the foundation for developing the theoretical framework. It will focus on the project delivery method and the awareness and knowledge of lean principles as related to project delivery at Eskom. The literature review is not meant to provide answers but will present an extensive review on the conventional project management process and how lean principles emerged and were applied to the construction industry.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The chapter on literature review offers several viewpoints from experts in terms of Project Management to the current day theme of Lean Project Management. The researcher provides various views on project management and lean practices in the execution and completion of projects.

2.2 Evolution of Project Management

The primordial approaches to management have been applied in business throughout history and this is evident in achievements such as the Pyramids of Egypt, the Taj Mahal and even the Colosseum in Rome (Tonnquist, 2008). These are what modern day man would term as large-scale projects that needed extensive administrative proficiencies in an era when this expertise was not widely known. Past research implies that there was no great management science behind these huge achievements as the actual study of management theories only began in the nineteenth century.

The advancement in general management led to the establishment of project management somewhere in 1960. Researchers believe that the project management concept, of the modern day, originated from the scientific era that was pioneered by moguls such as Frederick Taylor, Henry Gantt and Fayol. Project management gained momentum from when it was introduced by Gantt as a scheduling tool to being used by the military and finally embracing all industries. The scientific management theories postulated that one could apply logical and systematic tenets to any management activity. More importantly Gantt's development of a range of charts, which could measure actual units against planned units as well as pinpoint reasons for variances, was a major breakthrough. Today this tool is widely used as a scheduling technique to measure and track the progress of projects (Chui, 2010).

Project management has evolved from mirroring the classical school to aligning itself to the human relations school of management with greater emphasis on stakeholder requirements. Since then project management has earned its distinctive reputation as a specialist discipline.

2.2.1 Definition of a Project

Before one can identify with project management, one needs to appreciate what a project really is. In literature there exists many explanations of a project but the most apt definition is the one mentioned in the PMBOK (2013). The PMBOK defines “a project is a temporary endeavor undertaken to create a unique product or service”. “Temporary signifies that every project has a definite start with a definite end. Unique purports that the product or the service is distinctive in some unique way from all other similar products or services” (Burke, 2013). Cleland & Ireland (2010) suggest “a project as any undertaking that has definite final objectives representing specified values to be used in the satisfaction of some need and desire”. Whilst Tuman (2011) defines a “project as an organization of people dedicated to a specific purpose or objective, projects generally involve large, expensive, unique, or high risk undertakings which have to be completed by a certain date, for a certain amount of money, with some expected level of performance”.

It is evident from the above definitions by various renowned authors that a project at the very least must include specific objectives that must start and complete within predetermined dates by using appropriate resources to deliver the end product. The researcher can therefore conclude that a project is any unique attempt to produce a product within defined time, cost and quality.

2.2.2 Project Management fundamentals

The discipline of project management concentrates mainly on three constraints time, cost and scope which form the three most essential and paradoxical constraints that all projects endure. The project management triple constraint is about weighing each constraint with the aim if reaching a best solution. Arguably, it may not be possible to change one of the constraints with affecting either one or two of the other constraints. Each of the constraints is shown at the vertices of the triangle with quality in the centre. That is because any change to time, cost or scope of the project may affect the quality, so quality goes in the center of the triangle as a central theme.

Figure 2.1: The Project Management Triple Constraint, (PMBOK, 2013) I would move the figure away from the text.

2.3 Project Management

Project management is defined as a specialized domain of management, which has advanced such that the complex activities are able to be coordinated and controlled in a systematic manner. The dynamic economic situation of the 21st century has propelled organizations to continuously pursue more profitable solutions under the perimeter of project management. Projects are unique and exist in open environments therefore making them more adaptive to the dynamic nature of business.

With reference to the PMBOK project management is the application of knowledge, skills, tools and techniques to project activities in order to meet stakeholder's needs and expectations from a project (Burke, 2013). Kerzner (2013), the project management guru defines "project management as the planning, organizing, directing, and controlling of company resources for a relatively short-term objective that has been established to complete specific goals and objectives".

It is evident from the definitions above that projects are undertaken to satisfy the needs of the stakeholder, therefore organisations need to ensure that they use processes and systems that are able to deliver stakeholder expectations. The Figure 2.2 below represents the typical life cycle of a project.

Figure 2.2 – Project Life Cycle Model (Source: PMBOK, 2013)

Project Phases according to the PMBOK (2013):

- Initiating Process Phase: this phase consists of those processes that are performed to define or a new phase of an existing project by obtaining authorization to start the project. The initial scope is defined and financial resources are committed.
- Planning Phase: this phase consists of those processes that are performed to establish the total scope of the project, define and refine the objectives. The project management plan will be compiled together with the project documents that will be used to carry out the project.
- Executing Phase: this phase consists of those processes that are performed to complete the work defined in the project management plan to satisfy the project specifications. This involves coordinating people and resources as well as integrating and performing the activities of the project in accordance with the project management plan.
- Monitoring and Control Phase: this phase consists of processes required to track, review and regulate the progress and performance of the project; identify areas that require changes and initiate the changes.
- Closing Phase: this phase consists of finalizing all activities across all the phases to formally complete the project.

Within the above-mentioned processes are sub processes, which together form the framework in which projects are completed. Project management provides project managers with a structured and disciplined framework as well as rigorous business tactics and processes to expedite projects.

Project management is a sophisticated discipline that needs comprehensive processes that will assist in delivering the project within time, cost and quality. The most important processes in project management are the project schedule (time) and cost control. Larson and Gray (2014) on the other hand imply that project management is fast becoming a standard way of conducting business as it is moving away from being known as a special needs management philosophy. Therefore, irrespective of the scope or complexity of a project, the key principle is to deliver the project within cost and time.

Project cost and time are fast becoming the most crucial elements for both the stakeholders and the construction companies that are executing these projects. Any anticipated or unforeseen delay is likely to impact the cost and time ultimately causing delay to the client. Subsequently when a project is behind schedule the result is penalties, which are related to time, cost and quality (Danso & Antwi, 2014). Projects require successful administration based on the three major elements, time, cost and quality, which are a project's lifeline. Over time the project becomes wasteful due to time and cost overruns (Mulla & Waghmare, 2015). According to Kaming et al (1997), there are eleven factors that impact time and seven factors that impact cost in projects. Some of these factors affecting time are inadequate planning, material availability, and discrepancies in the bill of materials, labour unproductivity, changes in the design package, poor construction methods and lack of skilled resources. Some of the factors affecting costs are inaccurate costing estimates, payments made for work completed, inefficient management of the contract, material shortages, design amendments during construction, inclement weather and disparities in the contractual agreements (Omoregie & Radford, 2006).

It is apparent from the various authors that problems do exist in the execution of projects within the principles of project management.The literature identifies several causes for time and cost overruns (Rahiman et al, 2013). Table 2.1 lists the various causes relating to project time and cost overruns as identified by Rahman et al (2013) and Olawale & Sun (2010).

Table 2.1 Factors causing project cost and time overrun (Rahman, et al, 2013; Olawale & Sun, 2010)

Category	**Factors for Time and cost overrun**
Material	Fluctuation of prices of materials
	Shortages of materials
	Changes in material specification and type
	Delay in delivery of materials
	Dependency on imported materials
Manpower	High cost of labour
	Shortage of skilled labour
	Severe overtime
	Labour productivity
Money	Financial difficulties of owner
	Delay payment to supplier/subcontractor
	Delay in progress payment by owner
	Cash flow and financial difficulties faced by contractors
	Poor financial control on site
Machinery	Equipment availability and failure
	Late delivery of equipment
	Insufficient number of equipment
Unforeseeable conditions	Unpredictable weather conditions
	Risk and uncertainty associated with projects
Management	Lack of proper training and experience of PM
	Complexity of works
	Lack of appropriate software
Engineering/Contract	Design changes
	Discrepancies in contract documentation
Project Stakeholders	Conflict between project parties
	Non-performance of subcontractors and suppliers

Project delivery is a serious problem in Eskom KZNOU, as the company has endured poor safety and project quality, cost and time overruns and low efficiency of project staff,

unskilled contractor staff, poor designs, late designs, lack of availability of materials and low productivity. Howell & Lichtig (2008) have identified several problems affecting project delivery. Figure 2.3 provides a list of typical problems currently overwhelming the project environment. The underlying theory is to manage projects like a production system as this potentially allows for a change in the make-up of the design and in the construction works.

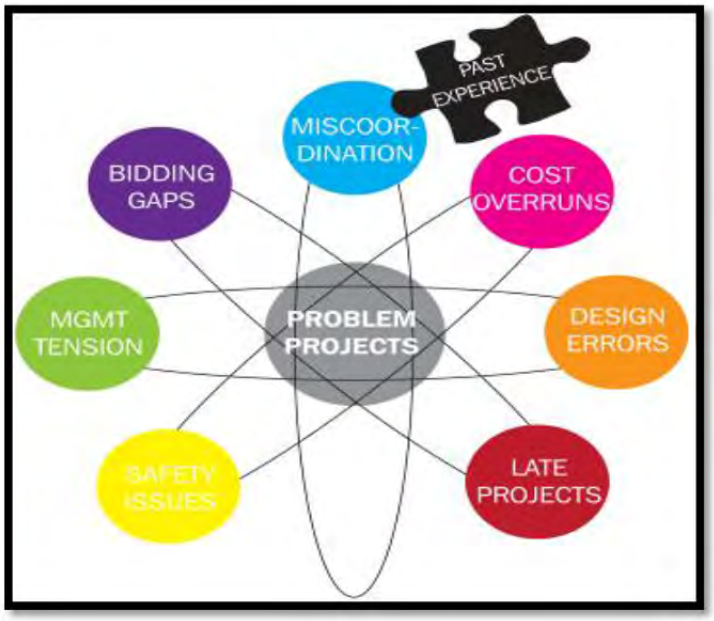


Figure 2.3 Factors affecting project delivery (Source: Koskela et al. 2002).

The adoption of lean manufacturing principles to the construction is an innovative approach for managing and improving construction processes by reducing cost and maximizing value simultaneously taking customer needs into consideration (Koskela et al. 2002).

2.4 Deficiencies in the Conventional Project Management Method

The application of project management as qualified by project management institutions needs to be rehabilitated as its performance is crashing because projects are becoming more undefined, complicated and constrained by time. Many renowned authors have examined the theoretical substance of the project management discipline and new methods have emerged, such as Last Planner and Scrum, which deviates from the traditional project management. These methods surfaced in response to the failure of project management. Scrum is used in the software projects and Last Planner is used in the construction of projects. Koskela and Howell (2002a; 2002b) have backed the new models and exposed the underlying foundation of the traditional project management model as flawed. The earlier writings show no

unequivocal project management theory and presumably, the PMBOK by the Project Management Institute offers a theoretical foundation of project management that is the applied science in the current environment (Koskela & Howell, 2002b).

Koskela and Howell (2000) alleged that the current project management practices are ineffective due to inconsistent theories and speculation in the industry. These inconsistencies include perceptions such as:

- The credibility of the theory;
- Empirical validity; and
- Other competing theories offering alternative methods.

The underlying principles of project management apply to the production model used in manufacturing industries (Koskela & Howell, 2002). It can be deliberated that the existing management processes can be improved by applying the production approach by adding the management of workflow and value creation to all activities.

Koskela and Howell (2002b) equate the traditional theory of project management to the transformation view in manufacturing. In this view, a project is theorized as a transformation of an input into an output. The project is managed by various principles, which entail the following points:

- Breaking down the transformation hierarchy into smaller manageable tasks, thus reducing the cost of each task.
- Management-as planning model that was outlined by Johnston & Brennan (1996) contains the initiation, modification and execution of plans.
- In the dispatching model, the contractor implements scheduled tasks.
- The thermostat model represents management control and entails the following elements:
    - A standard of performance;
    - A performance measurement at output stage; and
    - A measurement tool to measure variances between standard and actual. This tool assists with corrective actions.

The above model is the same as the theories of production as documented by various scholars. Koskela and Howell (2002b) have evaluated the conventional project management theory via the following evidence:

- The plausibility and consistency of the theory;
- Empirical validity;
- Competing theories; and
- Alternative methods based on competing theories (Koskela and Howell 2002b).

The evidence obtained from the above source was noticeably consistent, thus signifying that the underlying theory of project management is flawed. Table 2.2 provides a summary of the study done by Koskela and Howell (2002b), whereby proving the theory of project management to be inadequate to deliver projects.

Table 2.2 Underlying theory of project management (Koskela and Howell, 2002b)

Theory of Management	**Theory**	
Project	**Conceptualization:** Project is a transformation of inputs to outputs Principles: 1 The total transformation of a project can be decomposed into manageable and well-understood sub-transformations tasks. 2 A project can be realized in an optimal manner by realizing each task in an optimal manner and the tasks in optimal sequence. 3. Project performance can be performed by improving the tasks. **Assumptions:** 1. Tasks are independent, except sequential relationships. 2. Tasks are discrete and bounded. 3. Uncertainty as to requirements and tasks is low. 4. All work is captured by top-down decomposition of the total transformation. 5. Requirements exist at the outset and they can be decomposed along with work.	
Management	Planning	**Conceptualization:** There is a managerial part and an effector part in the project; the primary function of the managerial part is planning, and the primary function of the effector part is to translate the resultant plan into action. **Principles:** 1. Knowing the current state of the world, the desired goal

		state, and the allowable transformations of state that can be achieved by actions, a series of actions, the plan, can be deduced. 2. The plan is translated into reality by the effector part of the organization. **Assumptions:** 1. Translating a plan into action is a simple process, by following directions. 2. The internal planning of a task is a matter of the person to whom the task has been assigned.
	Execution	**Conceptualization**: Managerially, execution is about dispatching tasks to work stations. **Principle:** When, according to the plan, the time has arrived to begin task execution, it is authorized to start, in speech or in writing. **Assumptions:** 1 The inputs to the task and the resources to execute it are ready at the time of authorization. 2 The task is fully understood, started and completed according to the plan once authorized.
	Control	**Conceptualization:** There is a process to be controlled, a unit for performance measurement, a standard of performance and a controlling unit (thermostat control). **Principle:** The possible variance between the standard and the measured value is used for correcting the process so that the standard can be reached **Assumptions:** 1.The process is of continuous flow type, the performance of which is measured at aggregate terms 2. The process can easily be corrected by the control available.

It is clear that project management is becoming more inadequate as the underlying beliefs rest on flawed procedures and an overemphasized theory. The theory taken from lean manufacturing seems ideally suited for projects. Promising results in this regard have been

reached already in one project management area, namely in lean construction. Hence, lean production theory and principles were taken into consideration to be applied to construction (Howell & Koskela, 2000).

Academically the theory of project management cannot be outmoded; it needs to be revamped and reformed. Project management has not achieved the goals set to it: it does not perform in a satisfactory way. In small, simple and slow projects, the theory-associated problems could be solved informally and without wider penalties. However, in the present big, complex and speedy projects, conventional project management is simply counterproductive; it creates self-inflicted problems that seriously undermine performance. (Koskela & Howell, 2002).

It is therefore fundamentally important for project managers to pursue new contemporary management methods to realize maximum benefit with the least amount of time, cost and waste. Table 2.3 differentiates between project management and lean management.

Table 2.3 Differences between the conventional approach and the lean approach (Ballard, 2000; Sicat, 2012; Howell, 1999)

Activity	**Traditional Project Management Approach**	**Lean Construction Approach**
Control	Project control is represented in monitoring the performance (schedule and cost) and corrective actions taken after detecting negative variances (Ballard, 2000).	The role of project control is to assure reliable workflow by measuring and improving the system Performance (Sicat, 2012).
Performance	All the efforts of the management are concentrated on optimizing each activity separately, thus, reducing overall performance (Sicat, 2012).	The main target is maximizing value with minimum waste at the project level to assure reliable workflow (Sicat, 2012; Ballard, 2000).
Value	The customer has to define all his requirements at the outset of the project regardless of the change in markets and the new technologies (Sicat, 2012).	The project is managed as a value generating process where customer satisfaction is created and developed over the course of the project (Howell, 999).

Work techniques	Push-driven schedules are used to release information and material (Sicat, 2012). (E.g., materials are ordered to a pre-determined schedule to arrive on site before the work is carried out. If the stock is not used, the supplier continues to deliver to schedule.)	Pull-driven schedules control the information and material flow (Ballard, 2000). The team works backwards (pulls) from the end date to the start of the phase to identify the activities necessary to reach the end date.
Centralization	Decision-making is centralized through one manger.	Decision-making is through transparency by getting project participants involved in the production control system and empowering them to take action (Sicat, 2012; Ballard, 2000).
Under loading	Adjustments are not considered.	Production unit capacity is adjusted as well as inventory to be able to absorb variation (Ballard, 2000).
Variations	Variation's mitigation and management is not considered.	Variations are mitigated in respect of product quality and work rate (Ballard, 2000).
Collaboration	Such policy is not applied in the traditional methods.	Lean construction gives continuous support to suppliers by developing new commercial contracts, which gives the suppliers' incentives for reliable workflow and for participating in the overall product improvement (Howell, 1999).
Transparency	Transparency methods are not considered in traditional management methods.	Transparency is increased between all the project's stakeholders to allow people to make decisions reducing the need of central management (Howell, 1999).
Continuous Improvement	Traditional method does not consider continuous improvement so much.	Lean principles consider continuous improvement in the process and workflow (Howell, 1999).
Interactions and dependencies		Managing the combined effect of dependence and variation on activities is important as it affects the time and cost of any project (Howell, 1999).

2.5 Origins of Lean Thinking

Since the dawn of lean methodology a copious amount of literature has been published about lean principles and its application to business and construction activities. Lean management can be seen as a business improvement philosophy rather than a tool as it combines the various tools into a process. Stentoft & Freytag (2013) quoted, “lean management is a system for organizing and managing all aspects of a business function by creating principles, practices and tools in order to develop goods and services with higher quality and fewer defects”. Thus the expected consequence is a reduction in time, cost and effort used to deliver the end product (Kanigolla, Cudney & Samaranayake, 2014).

Lean methodology may perhaps be viewed as having components from Just-in-time (JIT) as well as tools and techniques from total quality management (TQM) (Arlbjorn, Freytag & Haas, 2011). However it must be stated that literature does not indicate whether or not lean principles are a practical approach to project environments (Arlbjorn, Freytag & Haas, 2011). Simultaneously lean processes allow a company to lessen waste by limiting inefficient processes and improving the overall value chain activities (Chual et al., 2010).

Although the lean methodology originated from a manufacturing industry, the principles are applicable to any organisation in any sector, often with some variation. In recent years many other service industries have implemented lean methodology due to added benefits.

2.5.1 Lean Construction Practices

Howell & Lichtig (2008) and Koskela & Howell (2002b) concede that projects need to be approached as production systems as this creates the possibility of transforming the nature of project work with the aim of maximising project performance. This makes reference to who does what, when, where and how. Thus lean principles present process optimization through collaboration, continuous improvement, and elimination of waste and customer satisfaction by delivering the value desired by the end-user (Enache-Pommer, et al. 2010). Introducing lean construction methods to production systems has increased the benefits of work flow of teams and materials which reduce inventories of work in progress and increases transparency (Sacks, Treckmann & Rozenfeld 2009).

According to O Connor & Swain (2013) lean is expressed as an effective, high-performance method for managing organisations and delivering their core purpose in the most efficient and effective manner while continuing to develop for a sustainable future. Lean is an ethos, a

way of doing business. It seeks to maximise the generation of customer value by driving out all forms of waste, ensuring 'right first time' quality, reducing timescales and minimising cost. There are basically five enablers of lean construction practices (Womack & Jones, 2003) and their applicability to projects is shown below.

The five Principles are:

- **Define Customer Value**: To determine from a customer's viewpoint what creates value for the customer. From a project perspective this could mean an electrification project completed within the specified design and functional performance criteria (Liker, 2004). From a customer viewpoint this value could mean the end product completed on or before the predetermined project end date within budget and the correct quality. By identifying this value the customer becomes the focal point for all participants associated with a project.
- **Value Stream Mapping**: To determine all through the value chain the necessary activities associated with a project. From a project perspective this means mapping all the activities, both direct and indirect, that is an end-to-end process and the non-value adding activities will become apparent. This will enable the project manager to identify the activities that add value to the customer, the activities that do not add any value but cannot immediately be purged and those activities that can be instantly eliminated. From a project perspective. From a customer's perspective non-value adding activities will be eliminated and the project team will not waste resources in an area that does not need it (Koskela & Howell, 2002).
- **Flow:** Once the non-value adding activities have been eliminated the next step would be to sequentially arrange all those activities that create value and make these activities flow. The most appropriate flow is where the tasks across the value chain do not stop.
- **Pull:** To determine which activity is customer driven and therefore make these activities just-in-time. This would entail delivering projects in line with customer needs. From a project perspective this will relate to coordinating the construction tasks to those the customers need. The objective is to ensure that the customer and the project team agree on a construction schedule where work programmes are integrated with regard to time and sequence of actions. One of the greatest advantages in this

principle is the reduction in lead times and increased flexibility (Koskela & Howell, 2002).

- **Continuous Improvement:** The Japanese refer to this as kaizen, which is continuous improvement. To strive for excellence in business activities through continuously improving processes will lead to a flawless organisation. The project team will need to implement improved work practices leading to increased performance, and lessons learnt must be used on other projects (Sacks, et al., 2010).

Figure 2.4 The five Guiding Principles of Lean (Bertelsen, 2002, Womack et al., 2003)

2.6 Waste Management

The key principle of lean processes is to eliminate activities in the value stream that are contributing to waste, which are frequently found in deficient or poorly managed processes. This results in excessive costs and time (Sacks, et al., 2010). O'Connor & Swain (2013) documented that the amount of waste related to projects is reported to be as high as fifty percent due to inefficiencies in the design and construction activities. The challenge to reducing waste is to define the procedure early enough in the value chain. Figure 2.5 illustrates the waste elimination process for a project.

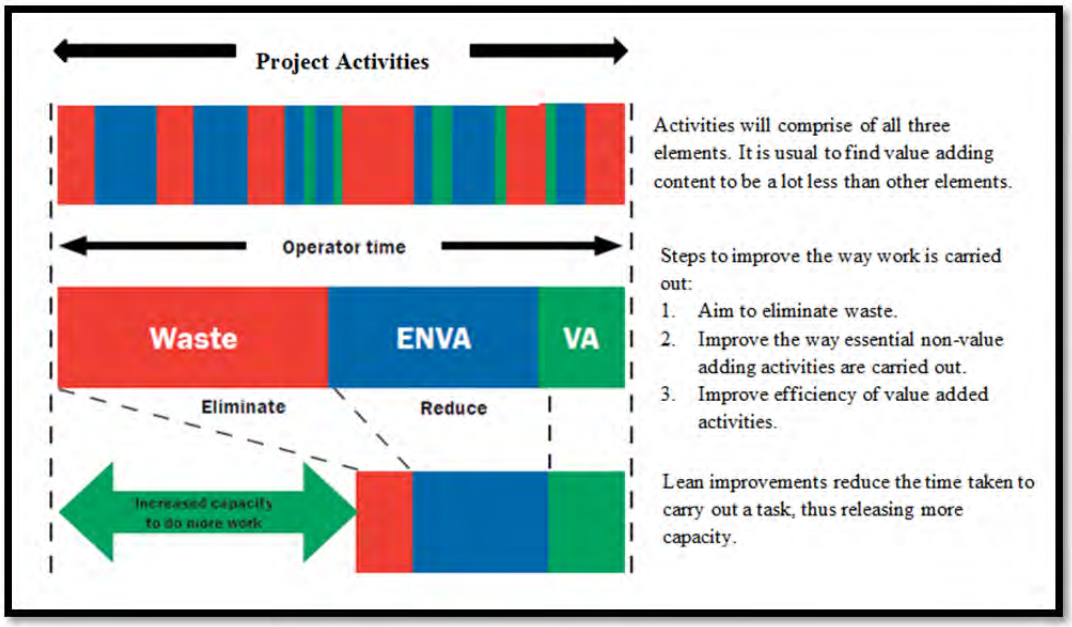


Figure 2.5 Waste elimination process (Adapted from O'Connor & Swain, 2013:2)

O' Connor & Swain (2013) identify three components in order to complete projects, namely:

- **A value adding (VA) component**: this is what shapes the final product and it is what the customer is willing to pay for.
- **Essential non-value adding (ENVA) component**: these are tasks to be completed so that the value adding task can be completed. These tasks do not necessarily add any value to the product. In a project this could be the quality inspection, which does not add actual value, but is necessary to complete the task.
- **Waste component: this can be observed in two ways**:
    - Waste in the actual task such as unnecessary movements, and
    - Waste that is introduced to the task, such as waiting for materials or work instruction. This has prevented the task from being completed.

Bell & Orzen (2011) and Garrett & Lee (2011) identified the following wastes, namely:

- Over-production
- Over-processing
- Unneeded Movements
- Defects in parts or processes
- Transportation which relates to unwarranted movement
- Inventory which impacts inventory costs in storage, handling, and obsolescence, and

- Waiting/under- utlised resources

Eriksson (2010) suggests that the above waste types can be reduced or eradicated by taking into account appropriate lean methods. Some of the tools that could be implemented are just-in-time material processes, information technology and housekeeping. On the other hand Sacks et al. (2009) introduced visualisation tools to lessen site uncertainties. It is evident from the literature that waste is not limited by productivity and material usage, but also from paperwork and information flow as acknowledged by Garrett & Lee (2011).

Bell & Orzen (2011) not only identified wastes linked to the manufacturing processes but also project management processes.

Listed below are wastes that are linked to projects (Bell & Orzen, 2011);

- Scheduling long, unproductive project review meetings.
- Collation of unnecessary/useless project related information.
- Maintaining a detailed schedule that is reactive in nature.
- Compiling/using status reports that tie up the project manager and the project teams, which seldom get read by key stakeholders.
- Preparation of project documents that are not used.

Lean project management focuses on reducing overall elapsed project time to break through the seemingly inherent trade-off of time, cost, and scope. The impact of the triple constraint in project management is lessened when waste is removed from business processes as well as project processes (Bell & Orzen, 2011).

2.7 Lean Project Systems

The lean project systems methodology as introduced by Ballard (2000) was based on the Toyota Product Development System which focused on the planning and design phases of the project. Emphasis was centred on target costing and a set based design. This system has been adapted and implemented in the construction industry, and which by no means is a completed product. The system incorporates many practices and work processes that have emerged in prior academic books and articles. Figure 2.6 provides a graphic view of the lean project delivery system (Ballard, 2000 & 2006).

The main idea behind the lean project delivery system was to redefine the entire system with specific emphasis on design, manufacture and use. Unlike the traditional project method

which optimised each of the sub-processes independently, this method separated the project into five phases as illustrated in Figure 2.6 (Ballard, 2000; Ballard & Howell, 2003).

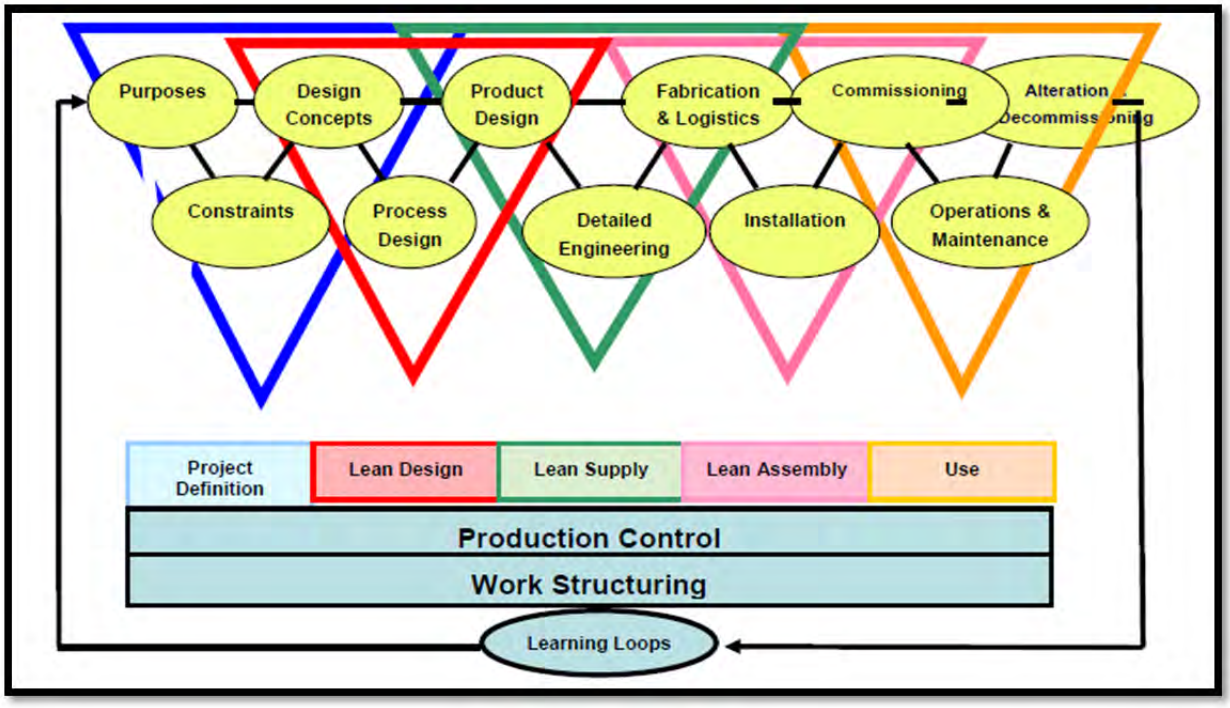


Figure 2.6 Lean project delivery system (Ballard, 2000 & 2006)

The definition phase would include business planning and validation, customer needs identification, design specifications, project cost estimates, project duration and project constraints. This stage would include collaboration between the customer, the project teams and the stakeholders. The lean design phase would include target costing, a conceptual design and detailed engineering. The lean supply phase would entail executing the design within the specifications of the detailed engineering plan. The major outcome of this phase is that waste is eliminated by means of minimising inventory at site and customer values is maximised. Once the materials are delivered to site, the lean assembly phase will begin. The project ends when all work is completed and handed over to the client. As illustrated in Figure 2.6 continuous flow process should be efficiently managed in each phase, or else the project will not succeed (Ballard, Lean Project Delivery System 2000 & 2006).

2.8 Lean Project Management

Lean principles focus on the eradication of waste by the use of visual techniques (Pepper & Tedding, 2011); whilst project management incorporates the use of project tools and techniques with the aim of meeting project obligations within the five process groups

(PMBOK, 2013). The lean methodology could be applied to projects by reducing the overall lost time on projects and finding symmetry between the three constraints. Lean methodology applies improvements to business processes and is applicable to project management methodology; by merely removing non value adding processes the consequence of time, cost and scope will be minimised.

The introduction of lean construction over the past two decades has definitely challenged the conventional management of projects. Historically project management was very constructive, however of late it is a precarious place to work due to time and cost overruns. The conventional practice would have linked these problems to poor communication, coordination and integration between the various participants (Chan et al., 2004). Research findings indicate that organisations and people seldom do what is required at the right time. As projects grew more unpredictable and complex, lean construction approaches grew more significant. Koskela, (1992) a visionary, introduced lean construction in an effort to deal with the problems associated with projects.

Lean is basically eradicating any form of waste from all facets of work in tandem with adding value to the activities in an efficient time and cost effective manner. Besides the manufacturing environment, lean management has been effective in all business sectors and project delivery areas by delivering value-added performance in time, cost and quality. Besides enhancing business activities, lean has assisted in developing organisations and their people resulting in a culture of continuous improvement. According to O'Conner and Swain (2013) the lean method must be applied from the start of the project as it will assist with defining efficient practices for pre-planning to the execution phase of the project. In addition lean principles can be applied to specific areas of a project or help recover a failing project.

Regardless of the noticeable differences in the nature of their assembly and construction processes, lean manufacturing and lean construction share some commonality. By all accounts manufacturing industries and construction projects are different in nature which justifies why lean practices are not suitable for the construction environment (Salem, et al., 2006).

2.9 Lean Techniques and Tools

There are numerous lean tools that can be implemented in the construction industry to improve the performance of projects. The lean techniques ensure that there are cost-effective

processes in the planning, execution and maintenance phases of the project. Table 2.4 shows a summarised list of lean tools and techniques that was explained in the literature (O' Salem, et al., 2006; Mostafa, 2011). The following passages provide a brief explanation of some of the lean tools and techniques.

- **Flow Variability Process**: this relates to production levelling mechanisms. By optimising the sequence of activities and batches in a production flow, the production volumes and resources can be controlled based on demand fluctuations (Ballard, 2000). The methods related to production levelling are standardised work procedures, activity sequence scheduling, functional layout and pre-emptive maintenance. Project processes are affected by flow variability as late completion of networked activities can affect the overall duration of the project. The last planner method as introduced by Ballard (2000b) is a technique that is capable of managing the plan proactively. This method provides an early task schedule that provides tasks that have been completed and those that need to be completed during the coming weeks. (Ballard & Howell, 2003). The last planners use these schedules to plan the week ahead and if tasks are not completed according to the schedule they will need to determine the cause and develop the action plan to prevent recurrence of the problem.

- **Process Variability**: Autonomation is a view that instantaneous action must be taken to avert defects at the source to prevent it from flowing through the entire process (Ballard, 2000). Visual management allows for workers to spot defects early and stop the process by using fail safe mechanisms. This technique prevents the defects from flowing to the next activity. Projects are subject to many variations during the life cycle leading to inconsistencies and uncertainty in the process (Hook & Stehn, 2008). In projects quality is focused on conforming to the design. Thus fail safe mechanisms can be applied on the job to ensure compliance to quality standards are adhered to.

- **Transparency**: the lean principle adopts the standard that any activity that does not add any value is considered as waste and should be removed from the process (Ballard, 2000). Lean methodology identifies the five S's, which are sort, straighten, standardise, shine and sustain. In project management this technique could be used to allow for transparency at site, which permits a free flow of materials from the project site to actual construction (Hook & Stehn, 2008). As every project has its own

construction site, applying visualisation techniques can assist with the work flow and daily action plans (Moser & Dos Santos, 2003).

  - Visual management: this technique is crucial in construction projects as it helps to map the work flow and allows the project team to be aware of the action plans at the project site (O Salem, et al. 2006). Visualisation shows the activity status of completed tasks, resource allocation and material availability. The use of signage, milestone charts and safety signs are important elements in the execution of projects (Sacks, Treckmann & Rozenfeld 2009).

- **Continuous Improvement**: this technique cannot be associated with any one type of process, as this practice is used in many processes. Continuous improvement in construction processes can be categorized as process improvement and operation improvement (O'Connor & Swain 2013). In manufacturing concerns quality circles are an ideal opportunity for all employees to work together to find optimal solutions for improvements in the process. Project managers can make use of continuous improvement methods to help to reduce variability and to improve the work flow (Sacks, et al. 2010). All the lean techniques support continuous improvement principles (O' Salem, et al. 2006).

- **The Pull Approach**: the lean approach uses "pull" scheduling as a production technique and the project methodology focuses inherently on activity planning (Ballard & Howell, 2003). As such resources are acquired and allocated in accordance with the project schedules, however value adding activities are only performed until the plan "pulls" forward the materials and resources (Johansen, 2002). Pull scheduling is a fundamental lean technique used to enhance work flow in projects (Thomas, et al. 2003).

  - Collaborative Planning: this technique brings together all stakeholders involved in a project to jointly agree on the plan. This is beneficial as it could be used any time during the project life cycle to recover cost and time overruns.

- Last Planner: this technique is associated to the pull approach as it supports the construction process by relying on the early task schedule. The project manager can use the schedule to determine if there are any potential constraints and recover them before the issue impacts cost and time. If there are variances between planned and actual then the project manager is able to determine the root cause and explain the variance.
- Just-in-time Material Process: this technique is ideally suited for projects, as it leads to fewer inventories at the project site and improved site management. Simultaneously costs are kept at a minimum as this pull system responds to customer demand (Australia, 2012).
- Visualization Technique: This technique is vital as it avoids uncertainty in the construction process. The work flow is identifiable and assists in creating awareness of actions on site as well as completed work. This tool assists in improving planning, control and has the propensity to reduce wasteful activities within the process (O' Salem, et al. 2006). The use of construction signs, notice boards, milestone charts and safety signs are some of the forms of visualisation.

2.10 Application of Lean in the Industry

The lean philosophy is rapidly permeating the industry to transform the conventional project management process. Lean principles were rolled out in many construction sectors as indicated in the following sections, which summarizes some of the applications of lean.

2.10.1 Construction supply chain

An empirical study took place to show the possible improvements in applying lean concepts to construction supply chains. This study concentrated on the theory of waste and its application to supply chains. The results concluded the use of value stream mapping (VSM) and was a reliable tool to improve supply chain performance. In addition to this many other lean tools were implemented to reduce batch size, involving suppliers at the design phase and standardising the process to improve performance (Arbulu & Tommelein, 2002).

A study in Brazil examined the application of value stream mapping (VSM) on the aluminum supply chain from raw materials to the job site installation. It was concluded that VSM shows

a high potential to help the application of lean concept beyond job site (Fontanini & Picche, 2004).

2.10.2 On-Site Subcontractor Evaluation

The growth in the construction industry has caused the large contracting firms to concentrate on core activities only and sub-contracting the tasks associated with project completion, thus collectively increasing complexity in managing construction activities. This caused disputes on site and poor performance by the subcontractors. A study in Chile was conducted to develop on-site evaluation methods for subcontractors based on lean principles and partnering practices. The on-site subcontractor evaluation method was achieved through implementing periodic evaluations and visualization tools to improve the communication between the subcontractors and main contractors Using lean techniques assisted in resolving disputes, and helped the subcontractors' supervisors to monitor their workers on-site performance (Maturana, et al. 2007).

2.10.3 Construction Submittals

As indicated project management focuses on the conventional model that considers conversion processes, which can be divided into sub processes (Koskela, 1992). For example, the project cost estimates are based on historical data from previous projects. These cost estimates are associated with a work breakdown structure (WBS), which is a breakdown of the tasks into smaller tasks. The unit costs of the major processes are the sum of the cost of each of the sub processes. A delay in the construction submittal can adversely affect the project schedule. Thus, improving the office activities is essential in any construction project for a better workflow on site. A study carried out by Gareth & Lee (2011) of construction companies in San Diego proved that by applying lean concepts in an office process as the submittals process, considerable improvements have been noticed. These improvements include time reduction by eliminating wastes and reducing non-value adding activities (Garrett & Lee, 2011).

2.10.4 Improving variability in construction

An empirical study carried out by Thomas et al., (2002) studied the issue of variability in construction projects and its impact on project performance using data from 14 concrete formwork projects. Thomas et al., (2002) concluded that reducing the variability in labour

productivity is more intensely correlated to better performance than reducing workflow variability.

2.10.5 Construction projects

The Nigerian construction industry was experiencing challenges in adapting to new construction techniques to eradicate waste and improve the value of the product. A study took place in Nigeria which evaluated the practicality of implementing lean project techniques in the construction process for 300 housing entities for low income households. The researcher carried out a field study to examine the effectiveness of the last planner system (LPS) and visualization methods as compared to the conventional project techniques and to evaluate the process of eliminating waste. The outcome with the implementation of LPS showed remarkable improvement in the production of houses, even though some of the project teams were not familiar with the method. The outcome showed improvements in time management that lead to huge savings in the project cost. The project was completed in 62 days using lean techniques instead of 90 days (Adamu & Hamid, 2012).

The construction industry is plagued by low productivity and high costs. Desai & Shelat (2014) conducted a study into the use of VSM to increase productivity, remove wasteful activities and reduce costs. This study reviewed the concepts of VSM to understand how the lean concepts can reduce non-value adding activities in construction projects and to create a road map to improve areas between the as is state and the proposed state. The study concluded that with the implementation of VSM concepts project managers were able to identify and measure sources of waste, reduce costs, improve the management of resources on site, decrease the variability issues, improve quality issues and reduce material and energy usage (Desai & Shelat, 2014).

Another study took place to show how VSM can improve the performance of civil engineering projects by allowing the site management to visualize the flows of materials, resources and information. This was examined through the fixing of reinforcement in two bridge construction projects. The results showed improvements in lead-time, inventory levels and improved costs by approximately 80% (Simonsson, et al. 2012).

2.11 Assessing and Evaluating Lean Techniques

Lean construction adopts the concepts of lean thinking and lean principles drawn from production management to create a new way to manage projects (Womack & Jones, 2003). Due to the rapid nature of the construction environment, project sponsors are requiring projects with shorter completion dates thus causing projects to become more uncertain and complex. This puts undue pressure on construction companies forcing them to find new methods of becoming competitive. The lean methodology is speedily circulating in the construction sector as a channel towards improved process flexibility. It is important that the project management fraternity understand the current state of the lean philosophy so that companies wanting to implement the techniques will be able to see the potential benefits.

A study carried out by Vieira et al. (2012) proposed the use of the Rapid Lean Construction-Quality Rating Model (LCR). This model was implemented in two construction companies to ascertain the performance levels of the uses of lean tools, to assess how it was understood and how it was applied to projects. The result of the survey was appraised and recommendations were made to both the companies. The outcome was positive, as it was possible to get results concerning the implementation of lean principles (Vieira, et al., 2012).

It is evident from the study above that the application of lean principles in the execution of projects has anticipated benefits and companies interested in implementing these techniques should be encouraged to do so. Lean benefit realization management (LBRM) is a systematic way of ensuring that the outcomes of a lean improvement programme deliver benefits that are advantageous to stakeholders (Smith, 2013). Many construction companies are adopting the lean philosophy as the preferred way to do business. Lean methodology is an excellent return on investment due to increased customer satisfaction and sustainable value for the construction and engineering companies (Bradley, 2010).

2.12 Concluding Remarks

Eskom is under severe pressure to fulfill its obligations to government, which in turn needs to deliver on its electrification targets as detailed in the National Development Plan. With Eskom's financial constraints, there is a dire need to streamline its current operations. Taking into consideration that overhauling the current model would be an expensive and time consuming exercise, the researcher aims to assess the impact of applying lean principles to Eskom's current project life cycle model in order to realize cost savings, release latent value as well as optimize its efficiencies.

The above chapter provided an extensive review on the appropriate literature for the study. Many aspects of the lean philosophy were addressed together with its applicability to the project environment. The next chapter focuses on the chosen research methods.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

This chapter reviews the research approach followed by the researcher and provides detailed insight into the structure of the study. Research methodology will introduce the population and sampling process and the manner in which the survey was executed.

3.2 Types of Research

There are two types of research that can be carried out in the work setting, one is applied research and the other is basic research. The first type is undertaken when researchers want to solve a particular problem in the business and the second type is when studies are carried out to create more knowledge on a particular area of concern with the purpose of finding a solution to the problem (Sekaran and Bougie, 2013). The purpose of this study is to create awareness and expand the knowledge around the area of lean management, hence the suitability of basic research. The focal point of basic research is theoretical and this study aims to enhance general understanding of lean principles thus enabling the company resources to work more efficiently.

Babbie (2013) confers that there are three types of research designs, namely descriptive, exploratory and explanatory, depending on the nature of the study. The aim of descriptive studies is to collect data that will provide a description of situations or people and is either qualitative or quantitative in nature. These types of studies investigate the associations between variables with the aim of finding relationships between such variables. Exploratory studies are conducted when there is limited available information about the problem; therefore, the research is directed towards understanding the problem and assessing the extent of the problem. In many cases, this type of research is not aimed at giving irrefutable evidence, but merely providing in-depth knowledge of the problem. Saunders, Lewis & Thornhill (2007) caution that when executing exploratory research, the researcher needs to be cognizant of the fact that new information will present itself coercing the researcher to change direction because of this. Explanatory research or casual method is applicable when the researcher wants to determine the cause and effect relationship between the variables. In this, instant researchers want to find out how variables interact and come together.

In this study, the researcher's main aim was to evaluate the current process applied to deliver projects and the impact of using lean principles to improve the delivery and performance of projects specifically at Eskom KZNOU. Therefore the researcher embarked on an exploratory study with the aim of elucidating the applicability of lean principles and to provide an understanding of the problem (Saunders, Lewis & Thornhill, 2007).

The reason for embarking on the study was due to the constant problems hindering the delivery of projects within cost, time and quality. Some of the problems encountered in delivering projects are time delays, cost overruns, budgetary constraints, poor quality, safety and contractor disputes (Teicholz, 2004). Therefore as an alternative the researcher decided to investigate the applicability of lean principles, in order to ascertain whether lean principles can improve the delivery of projects. Before embarking on the research, it was essential to define the topic, research questions and the purpose of the study.

The previous chapters provided a synopsis on project management principles as well as lean principles, which was gathered using secondary research. The information collected from the literature research and the information from the empirical study will be used to gauge if the objectives of the study are supported.

3.3 Data Sources

Data collection involves both primary and secondary data and it is important to differentiate between the two. Firstly, primary data is original data that is collected from the field by the researcher for a specific study. Researchers would normally embark on primary research especially when the required data is not available from printed sources. Primary data collected could be used for future research. Subsequently, the researcher used the in-house mailing system to alert the target population of an impending study.

Secondary data is data that has previously been collected and is available from a variety of source documents. This data has been collected for purposes other than the specific study at hand. Secondary data may be relevant to the study being carried out and suitable enough to draw conclusions as it produces defined data. The assemblage and evaluation of secondary data customarily expands the researcher's interpretation of the problem and assists in steering the researcher along a particular path. The following sources of secondary data were used:

- Previous research
- Mass media products

- Government reports
- Web information
- Historical information
- Books

This dissertation made use of both primary and secondary data sources. Secondary data as referenced in Chapter 2, covered the theoretical framework and was used to understand the applicability of lean principles in a project environment and to create an awareness of lean principles. Primary research was applied to gather elemental data on the manner projects are executed within time, cost and quality at Eskom. The next section will provide a view on the research design method used to gather data. Reference

3.4 Research Design

Any research being carried out needs a structure before the researcher can initiate the data analysis (Jackson 2011). A research design is a work plan designed to ensure that the acquired data allows the researcher to answer the research objectives unequivocally. Obtaining the appropriate data compels the researcher to specify the type of evidence that is required to answer the research question. Thus the researcher needs to ask; given the research question, what kind of evidence is required so that it answers the research question (Sekaran & Bougie, 2013). Research designs are normally associated with qualitative, quantitative and mixed research methods (Denzin & Lincoln, 2011).

The choice between quantitative, qualitative or mixed design approaches is a significant one. Nevertheless, the decision between the design structures must be done (Bryman & Bell, 2007). Babbie (2013) and Kent (2007) state the key difference between quantitative and qualitative is that one is numerical and unstructured and the other is non-numerical and structured. Quantitative research is a systematic process of collecting numerical data from a sample population by generalizing the findings to the total population (Maree, 2009). This approach has the ability to implement statistical models to the gathered data in a non-biased manner. A quantitative research approach makes use of deductive analysis between a hypothesis and empirical evidence (Bryman, 2007). This means that the researcher will formulate a hypothesis, collect primary and secondary data, analyse this data and make conclusions to prove the hypotheses true or false.

Qualitative research on the other hand focuses on words and descriptions rather than numbers and comprises focus groups, case studies, interviews, experiments and open-ended questionnaires. In qualitative research, the emphasis is on behaviours and real life situations within the broader situation. Conversely, this method is reproached for being dependent on the idiosyncratic explanations of the researcher and not capable of being replicated by ensuing research (Bryman, 2007).

Lastly, the mixed methods approach uses both qualitative and quantitative methods. Some researchers will opt for this approach in order to overcome the shortcomings of a distinct research design method. This method is easy to design and can position the research in a transformative context.

This study was classified as quantitative in nature and a questionnaire with closed questions was the chosen methodology for conducting this research. A quantitative analysis was selected as the preferred method as the representative sample was greater than 30. Using this numerical approach has uncomplicated the process of managing the research data as this can be displayed graphically and in table format.

3.5 The Questionnaire Structure

The approach used for this study was a questionnaire, which was administered internally at Eskom. The aim of a questionnaire is to obtain factual evidence from the sample population and to standardize the format for recording this information (Hague, 1994:12). Saunders et al (2007:279) provide the following advantages of improving response rate and the reliability of the data:

- A clear layout of the questionnaire;
- A clear explanation of the intention for the study;
- A carefully design of individual questions; and
- Conducting a pilot study.

3.5.1 The Questionnaire Design

According to Leedy (2001:202), the intention of the questionnaire is to extract information that will support the research study, therefore the following need to be considered when designing a questionnaire:

- It must be only long enough to elicit the required information.

- The language must be clear and concise.
- There must be no assumptions implied in the questions.
- There should be no indication given on what the preferred answer would be.
- Include questions that will verify respondents' viewpoints.
- Know in advance how the responses are to be coded.
- Instructions must be stated unambiguously.
- Ensure that questionnaire is skillfully done.
- Conduct a pilot test.
- The final product must be carefully scrutinized.

Chapter two on the literature review provided a structure for the data that would be required from the questionnaire. The questionnaire was adopted from a previous study that was carried out in Egypt (Swefie, 2013). The questionnaire was reviewed and minor changes made to align to the current study. It was pivotal for the researcher to determine if the employees were knowledgeable on lean principles and if they understood the existing methods used to deliver projects. Hence, the questionnaire included written sets of questions, which allowed the respondents to record their answers from a list of alternatives. The questions were mostly close-ended questions. The researcher opted for this approach, as it was more convenient than interviews or observation techniques.

3.5.2 The Layout of the Questionnaire

The questionnaire was intended to ensure the respondents were able to effortlessly complete it and precise enough for the researcher to analyse the data. Allison et al (1996:75) suggested the following sections to be included in a questionnaire:

- Title of the research study.
- Introduction to provide assurance of confidentiality and anonymity.
- Instructions to complete the questions.
- Demographic data of respondents.
- Core data: the focus of the empirical study.
- Closing remarks: to thank the respondents for participating in the survey.

Questionnaires can be administered either personally, by mailing or by distributing it electronically (Sekaran & Bougie, 2013). Administering the questionnaire personally offers far more advantages as the researcher is able to collect all the responses much quicker than

the mail or electronic surveys. The researcher is able to provide clarity to any misconceptions the respondents may have and is in a position to introduce the research topic. This method is less expensive and does not require complex skills to carry out the survey. The main disadvantage of this method is that the researcher could introduce bias by explaining questions in a different way to each respondent and therefore triggering the respondents to provide different answers.

Mail and electronically administered questionnaires can definitely reach a wider geographical area. This method allows the researcher to mail or send the questionnaire electronically whereby the respondents will complete the questionnaire at their convenience. The downside of this method is that the response rate is low. In addition, if respondents are unsure about certain questions, they will answer with uncertainty, as the researcher will not be able to provide the clarity (Morgan, Gliner, & Harmon, 2006). The low response rate may cause difficulties for the researcher to confirm a representative sample.

The questionnaire was administered electronically using the internal mailing system of Eskom. The sample population was distributed across Durban, Newcastle and Pietermaritzburg zones of Eskom KZNOU. To improve the response rate an email was sent to the respondents advising them of the survey and thereafter follow up mails were sent to respondents urging them to respond and offering any clarification that may be required (Sekaran & Bougie, 2013).

The purpose of this research was to collect quantitative data that would be statistically analysed; therefore, the questions were structured in a manner that allowed the respondents to answer all questions. Survey questions can be grouped into open ended, closed ended and contingency questions (Sekaran & Bougie, 2013). Closed ended questions provide the respondents with alternatives, which may or may not reflect the respondents' opinions. The negative side of close-ended questions is that they do not allow the respondents to provide responses other than what has been suggested in the questionnaire. Open-ended questions do not offer respondents with choices; rather the respondent will need to respond with a short text, a word or a number. This may cause some discomfort to the respondents who may not be able to answer or analyze the questions. Contingency questions apply to a subgroup of respondents, which are triggered by a filter question. The filter question will lead the subgroup to answer a set of specific questions and directs others to skip that section of the

questionnaire. The advantage of this type of question is that it allows detailed data to be collected from specific respondents (Foddy, 1993).

The questionnaire was categorized into three sections, namely:

- Section A was designed to extract biographical information as well as the participants' background and work experiences.
- Section B was designed to identify the factors that affect project performance within the current processes.
- Section C was designed to assess the participants' understanding of lean principles and their application in a project environment.

The questionnaire is included under Annexure 2 of this dissertation.

3.5.3 Covering Letter of the Questionnaire

The reason for a covering letter is to notify the respondent about the survey that is being carried out and to invite the selected people to participate in the study. The covering letter will assure the respondents of confidentiality and anonymity. The researcher's contact details are included in the letter in the event of any additional information or clarity that may be required by the participants. This will also assist in increasing the response rate as it likely to influence the respondent's decision to cooperate with the requirements of the survey. The covering letter was written in a manner that minimized possible objectionable content. Lastly, the covering letter also included a consent agreement, whereby the participant will agree to take part in the survey. The cover letter is included as Annexure 1 of this dissertation.

3.6 The Pilot Study

Birch and Mauch (1998:124) define a pilot study as one that is done before the actual study is carried out in order to establish the feasibility of the study and to identify any problems or ambiguities that may exist. Given the intricacy of the questionnaire design it is impractical to get it correct the first time, therefore a pilot study was carried out before the main survey was rolled out. The questionnaire was tested on a small group of people representative of the survey sample. This allowed the researcher to detect and correct defects in the questionnaire design before commencing with the survey.

The questionnaire was disseminated to five respondents in the project execution department of Eskom before the actual survey was initiated. The selected respondents were not part of

the sample population for the actual survey. After the completed questionnaires were handed in, the participants were questioned with the aim of identifying problems in the design or ambiguity in the questions. The contributions from the pilot study helped to refine the questionnaire.

3.7 The Sample Design

According to Sekaran and Bougie (2013:242), "sampling is a process of selecting a sufficient number of the right elements from the population, so that a study of the sample and an understanding of its properties or characteristics make it possible for us to generalize such properties or characteristics to the population elements". A sample design is referred to as a plan for deriving the sample size from a given "population" or "universe" (Kothari, 2004). Sekaran and Bougie (2013) infer that "the population refers to the entire group of people, events, or things of interest for which the researcher wants to make inferences". It defines the technique employed by the researcher in choosing items to be incorporated in the sample. The sample process is decided before the actual data collection. A researcher can choose from the number of sample designs that are available and some are more complicated than others. Before the researcher could proceed with the sample design, the population needed to be defined in terms of geographical boundaries and times (Sekaran & Bougie, 2013).

The researcher contacted the communications department of Eskom and managed to secure the list of elements to be considered for the study. The list included all the employees that work in the project execution department of Eskom together with the support staff. The researcher needed to ensure that the target population met the specific characteristics of the particular research. There are two types of sampling design as per documented literature, namely probability and non-probability methods. The Figure 3.1 below indicates the two types sample designs.

Table 3.1 Basic Sample Design (Source: Kothari, 2004:59)

Element Selection Technique ↓	Representation Basis ↓ Probability	↓ Non-Probability
Unrestrictive Sampling	1. **Random Sampling**	1. **Convenience Sampling**

Restricted Sampling	2. **Complex Random Sampling**: 〉 Cluster Sampling 〉 Systematic Sampling 〉 Stratified Sampling	2. **Purposive Sampling:** 〉 Quota Sampling 〉 Judgement Sampling

From the above Table 3.1, it is evident that the sample design can be probability or non-probability sampling. The first sampling method includes simple random sampling, which means that some elements in the population have a probability of being selected. The second method is a "non-random" method, which means that the elements in the population do not have a known chance of being selected. Because of the element selection, it either could be restrictive or unrestricted (Kothari, 2004). Both of these methods have different sampling techniques.

The random sampling technique ensures that each element of a population has an equal and likely chance to be selected as part of the sample. Each element in the sample has an equal likelihood of been selected. The logic behind simple random sampling is, it removes any bias from the selection procedure and should result in representative samples (Gravetter & Forzano, 2011). Complex random sampling includes cluster, systematic and stratified sampling.

Cluster sampling is used when the population is heterogeneous or so large that the most appropriate method is to separate the entire population into subdivisions or clusters. These clusters are small units randomly selected within an already subdivided population. The use of cluster sampling certainly reduces the costs, as this method is economically advantageous (Kothari, 2004; Sekaran & Bougie, 2013). Systematic sampling comprises of selecting every *n*th element in the population by randomly choosing between 1 and *n*. this method is suitable if the sampling frame does not include "any form of periodicity that parallels the sampling ratio" (Cooper & Schindler, 2014:199). Depending on the sampling ratio the first elements are randomly selected and thereafter the remaining elements are based on a fixed interval. Lastly, stratified sampling involves segregating the population into mutually exclusive subgroups and then randomly selecting the elements from the stratum (Cooper & Schindler, 2014, Sekaran & Bougie, 2013). This method is highly efficient as it lends more evidence within the known sample size.

The non-probability method includes convenience and purposive sampling. Convenience sampling is almost always used in exploratory research and involves elements who are readily available to be included in the sample. This is probably the most convenient manner to collect basic information economically (Kothari, 2004). On the other hand, purposive sampling involves collecting data from specific types of elements as they have the required data or they have been selected by the researcher (Sekaran & Bougie, 2013). Two techniques are available under the restrictive sampling method, quota and judgement sampling. Quota sampling is used by matching what would be the most appropriate method to employ. This means that the elements are suitably represented in the sample population and are therefore deliberately selected (Cooper & Schindler, 2014). Judgement sampling is a technique used by the researcher who uses his/her own acumen to choose elements to be in the survey (Kothari, 2004). These elements are in the best position to provide the necessary information (Sekaran & Bougie, 2013). This technique is used when there are a limited number of experts with the particular knowledge and is limited to certain types of research questions. The above section provided a brief overview of the various sampling methods that are available to the researcher.

The researcher identified the population for this research as all elements who work at the project execution department of Eskom in the KZN Operating Unit only. The population will therefore comprise of the project staff and support staff. The sampling frame was obtained from the communications department of Eskom and included a current listing of all elements as identified in the target population. The following elements were identified in the sampling frame; the Portfolio Managers, the Programme Managers, the Project Managers, the Project Finance Managers, the Contracts managers, the Project Coordinators, the Clerk of Works, the finance officers, the Buyers, the Project Engineers and Designers. The researcher believed that by investigating this sample the researcher would be able to draw inferences that represent the total population.

The representative sample size was calculated using an on-line sample calculator (www.checkmarket.com/market-research-resources/sample-size-calculator, 2015). The population size as per the list from the communications department of project resources and support staff summed 80 elements. The researcher decided on a 95% confidence level indicating that 5% of the surveys will provide responses not in line with the survey. With a confidence level of 95%, the researcher invited 67 applicants and the expected response rate was 45%.

The questionnaires were mailed via the Question Pro System to 67 participants. From the 67 participants only 46 responded to the survey. An adequate response rate as mentioned by Babbie (2013) is 50% and in this study, a response rate of 53.7% was obtained. The response rate was maximized and the error rate was, to an extent minimized due to the pilot study that was rolled out.

The researcher had to contend with the prime choice: probability or non-probability sample. The researcher decided on a non-probability sampling method due to the ease of selecting the sample and it was much quicker and cheaper than probability sampling. Quota sampling was used to select the participants to be included in the study. The population was divided into subgroups. The researcher then arranged the population according to variables of importance to the study. The variables included the type of role and position the respondent held in the project as well as the number of respondents in each of the positions. The sample was as follows:

- 5% Portfolio Managers
- 11% Project Managers
- 5% Finance Managers
- 3% Contracts Managers
- 22% Project Coordinators
- 38% Clerk of Works
- 5% Finance Officers
- 3% Project Buyer
- 8% Project Engineer & Designer

The sample size is crucial to the study, as the researcher will need to ensure that it is representative of the target population so that the objectives of the study are met. If the sample size is too large the researcher could be triggering type II errors, that is, the researcher is likely to accept the findings of the research when in reality the findings should be rejected. Roscoe (1975) in Sekaran and Bougie (2013) recommend the following rules in determining the size of the sample:

- Sample sizes larger than 30 and less than 500 are appropriate for most research.
- Where samples are divided into sub samples, then a sample size of 30 is appropriate for each category.

3.8 Data Collection and Analysis Method

Data collection is central to the research design and can be collected from various sources depending on the available facilities, the time factor of the study, the researcher's adeptness, costs and resources and the level of accuracy required (Sekaran & Bougie, 2013). The researcher indicated earlier that the main method for data collection was via a survey whereby a questionnaire was administered to individuals working in the project environment at Eskom KZNOU. The survey was conducted and the researcher sent the questionnaire to 67 respondents working in the Electrification project execution department of Eskom.

The main purpose of this questionnaire is to measure the awareness of employees about lean construction in Eskom. This survey method was opted for the research as it offered the following benefits:

- The survey data was acquired within a shorter period.
- The data was moderately simple to capture onto a computer for analyzing purposes.

The following method was used to collect the required data:

- A questionnaire was mailed to the selected respondents using Question Pro System via the internet. The Question Pro System is an online tool that the researcher subscribed to in order to conduct the survey. The online system provided the researcher with the statistical analysis of the survey, which was incorporated into the research findings and was later discussed.

Data was collected from the selected respondents. The next step was to analyse the data. Before the researcher could delve into the exploration of the data, the researcher had to ensure that the data was conclusive and indubitable for further analysis.

3.9 Validity and Reliability

It is important to think about the validity and reliability of the study under investigation. Validity is a tool that is used to measure the quality of the research (Morgan, Gliner, & Harmon, 2006) and relates to the method and the design of the research. According to Morgan et al (2006), validity implies that the findings accurately reflect the event being measured. Validity is generally about the control of dynamics that could influence the study. It is practically impossible that a research tool can be very valid; therefore, validity is evaluated in degrees (Carter and Porter, 2000). Data validation is a process of gathering and

examining data in order to determine the accuracy of the tool (Peat, 2002). Validity is classified as either internal or external in nature.

Internal validity is associated with the mistakes that are within the research design and is a good test of the research question (Aguinaldo, 2004). The findings will be noted as internally valid especially if the data was not reasonable. The following factors can influence internal validity: subject variability, size of subject population, time given for data collection, history, attrition, maturity, and instrument (Seliger & Shohamy, 1989).

External validity tests the extent to which the sample represents the population or if the findings can be generalized in another context (Aguinaldo, 2004). The findings will be noted as externally invalid if they cannot be applied to another context outside of the current research. The following factors can influence external validity: population characteristics, interaction of subject selection and research, research environment, time,and data collection method (Seliger & Shohamy, 1989).

Reliability measures consistency across the items in the instrument (Sekaran and Bougie, 2013). It is improbable that the researcher will be able to calculate reliability; however, there are four “goodness of measures” that can be used to determine reliability (Trochim, 2006):

- Inter-Rater/Observer Reliability: The extent to which different raters/observers provide reliable answers.
- Test-Retest Reliability: The stability of a measure, which is evaluated over time.
- Parallel-Forms Reliability: The reliability of two tests constructed the same way, from the same content.
- Internal Consistency Reliability: The consistency of results across items, often measured with Cronbach’s coefficient alpha.

For the researcher to ensure validity and reliability, the respondents who took part in the survey were selected based on their professional backgrounds and the use of valid and reliable references from published literature were taken into account.

3.10 Research Challenges and Limitations

The study was limited to Eskom KZNOU only, with special emphasis on the project management methodology used to deliver small scale multiple projects in any given financial year. The focus was on employees who work in a project delivery environment and included

all levels of management and staff within the organizational structure, but restricted to the Electrification Department.

Nevertheless, the scope of this study was not to produce a completely new work practice, but rather to develop steps that the company can take in transit towards lean project management.

3.11 Ethical Considerations

Research ethics is concerned with the guidelines and specific doctrines that control research behaviour. The preferred research method chosen by the researcher will determine the approach taken towards ethical issues. Bryman and Bell (2007) indicate that researchers should comply with basic ethical principles throughout the research process, by following the code of ethics namely:

- Participation in surveys and in-depth interviews are voluntary.
- Falsification, fabrication and misinterpretation of data must be avoided
- Works of other researchers and authors used in research are referenced using the Harvard referencing system.

For the purpose of this research, the participants will be treated autonomously, meaning they will make independent decisions within the ambit of the proposed research. This forms the basis for informed consent, whereby the participants will be given all the information pertaining to the research and they will make the decision whether or not to take part in the research. A consent form was accompanied by the questionnaire, which addressed the following (Creswell 2007):

- The participants' right to withdraw from the study.
- The benefits and risks of the study.
- Confidentiality of the participants.
- Signatures of the researcher and participant.

The consent agreement assumed that the participants were competent to take part in the survey. This research protected the identity of the participants through anonymity of responses and confidentiality was maintained when writing the findings.

In contrast to qualitative research, which is subject to researcher bias, quantitative studies address the ethical dilemma by designing the research study as objectively as possible.

Throughout this research process, the researcher made use of systematic and statistical tools to ensure ethical guidelines were followed.

3.12 Concluding Remarks

This chapter provided the fundamentals of the research design, which culminated in the establishment of this empirical study. Primarily, it revealed the approach applied to conduct the research, which was qualitative in nature and was centered on sound references from literature that supported the research approach in view of the objectives of the study. After that the data sampling process, data collection process and data analysis were explained. In conclusion, the chapter summed up the research challenges and limitations and ended with a discussion on ethical considerations. The next chapter will review the results of the survey and the data will be analysed and interpreted.

CHAPTER 4

ANALYSIS AND INTERPRETATION OF RESEARCH FINDINGS

4.1 Introduction

The previous chapter streamlined the design method used in this survey as the chosen methodology for this exploratory study. The main objective for embarking on this study was to analyse whether lean principles can be implemented in a project environment to improve project performance and delivery. This chapter presents a consolidated view of the research findings, followed by a detailed data analysis of the study.

The data collected from the research was analysed and interpreted as per the questionnaire design, namely:

- Section A: this section dealt with the demographical information as well as identifying the participants' project experience.
- Section B: specifically dealt with general project management deliverables, which are time, cost, quality and scope of work.
- Section C: dealt with the participants' knowledge and awareness of lean principles.

4.2 Data Analysis and Interpretation of Demographical and Project Experience (Section A)

This section provided demographical information about the respondent's background and participants' project related experience. A summary of the respondents' demographical information was obtained from Section A of the survey. In this section, the respondents were requested to provide information regarding their age, level of education and related project experience. Each of the sub sections will be analysed.

The respondents' age varied between 18 years to 64 years, with 75% of the respondents falling in the 30 to 49-age category as illustrated in Figure 4.1 below. This indicates that the majority of the respondents fall within a mature and experienced age group or what is known as generation X. This category of respondents bring a high level of experience coupled with qualifications. The results indicate about 19% of the respondents fall in the 50 to 64-age category indicating a mature and old workforce that is nearing retirement age. The research

further indicated that there are no employees older than 65 years working in the project environment.

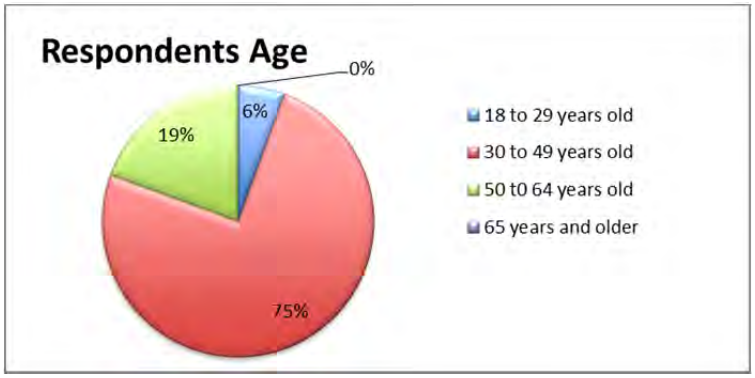


Figure 4.1 Age Category of Respondents

The Figure 4.2 below illustrates the summary of levels of education of the respondents. It is evident from the results of the survey that the majority of participants are highly educated. 50% of the respondents have a bachelor's degree and 17 % have a master's degree. 8% have some form of technical training and another 8% have completed some college training. 3% have an associate degree. Another 14% have noted their levels of education as a Government Certificate of Competency in Engineering, Accounting technician, Diploma in purchasing, Electrical Engineering and various in-house Management Programmes.

It is evident from the results above that the respondents are well educated as there are no respondents with just a high school pass. The results also indicate that the highest level of education is a master's degree.

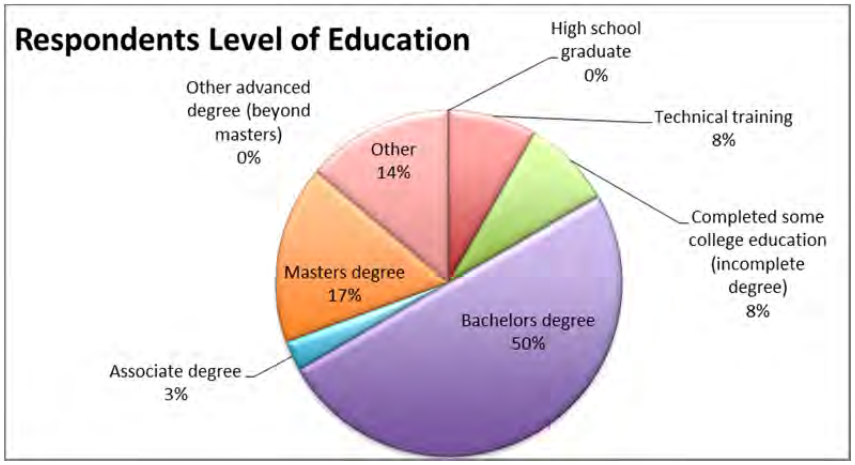


Figure 4.2 Respondents Education

The Figure 4.3 below represents the respondent's level of education. The respondents' work experience ranged from 5 years to above 20 years. This indicates a very experienced sample population. 42% of the respondents have between 10 to 15 years' experience, whilst 39% have between 5 to 10 years related work experience. A further 5% have between 15 to 20 years' experience and 6% are above 20 years work related experience. The results indicate about 8% of the respondents have between 0 to 5 years work experience, indicating a fairly young and innovative work class.

This is clear that the bulk of the respondents are highly skilled to perform the jobs they have been appointed to carry out, whilst simultaneously a small percentage have less than 5years experience.

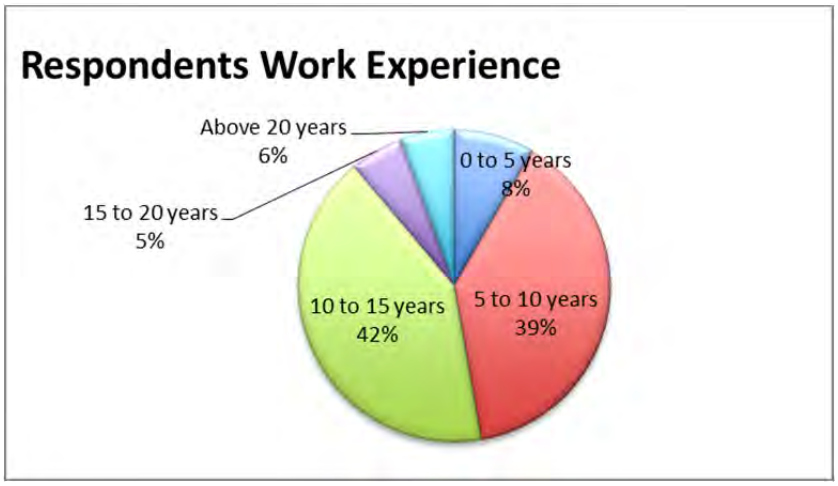


Figure 4.3 Respondents' Work Experience

The next three illustrations provide a summarized analysis of the specific project related experience of the respondents.

From the Figure 4.4 below, 25% of the sample population is employed as project managers and 17% as project coordinators. The quality control officers represented about 3% of the total sample. Another 6% of the respondents are in project finance, whilst 5% represented project schedulers. The results indicated that 5% represented portfolio managers and 3% were technical managers. Interestingly 25% of the sample populations were classified as other, namely:

- Project Systems Officer
- Senior Advisor: Procurement
- Project Pricing Analyst

- Project Planning Coordinator
- Project Engineer
- Contracts Manager
- Data Manager
- Quantity Surveyor

It is evident from the results above that the selected sample represented a wide range of professions in the project environment.

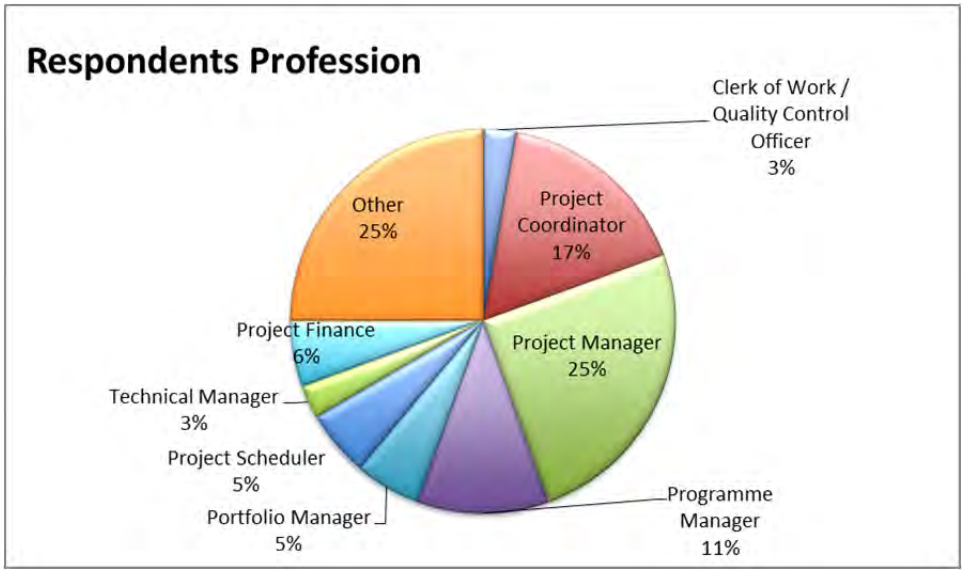


Figure 4.4 Respondents Profession

The Figure 4.5 below provides an indication of the types of projects the respondents work on. 31% of the sample populations have experience working on Greenfield projects, which are known as rural electrification household projects. These projects are new and exist to electrify the previously disadvantage population of South Africa. About 23% show experience working on Brownfield projects, which are projects that are initiated to electrify households in previously electrified areas. 21% work on line projects and 12 % on substation projects. Finally, 11% work on projects classified as link lines.

The latter three types of projects exist to create capacity on the existing networks in order to connect new customers as indicated in the Brownfield and Greenfield projects. It is clear that related experiences range between all types of projects, indicating a varied workforce.

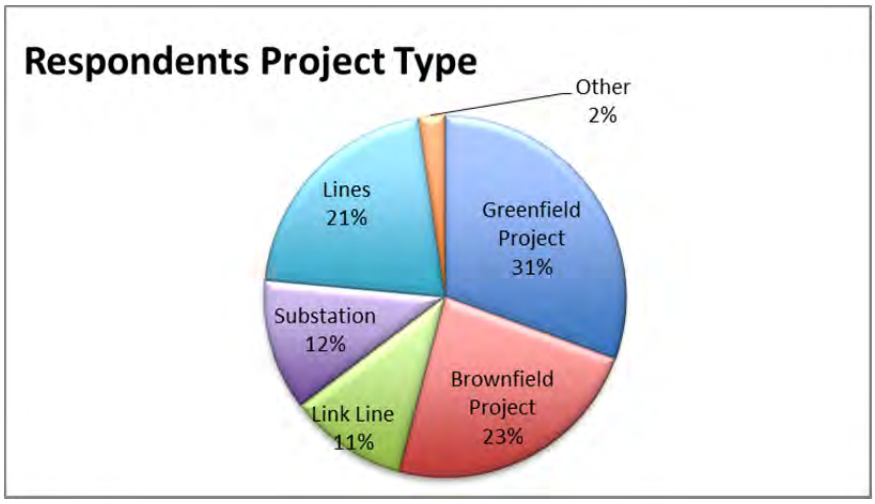


Figure 4.5 Respondents' Type of Project

The Figure 4.6 below represents the project values that the respondents work on, which varies between 1 million to 30 million. 32% of the respondents work on project values that range from 0 to 10 million and 20 to 30 million. Another 18% each work on project values ranging from 10 to 20 million and above 30 million.

There is an equal split between the project values indicating some form of correlation between project types and project values.

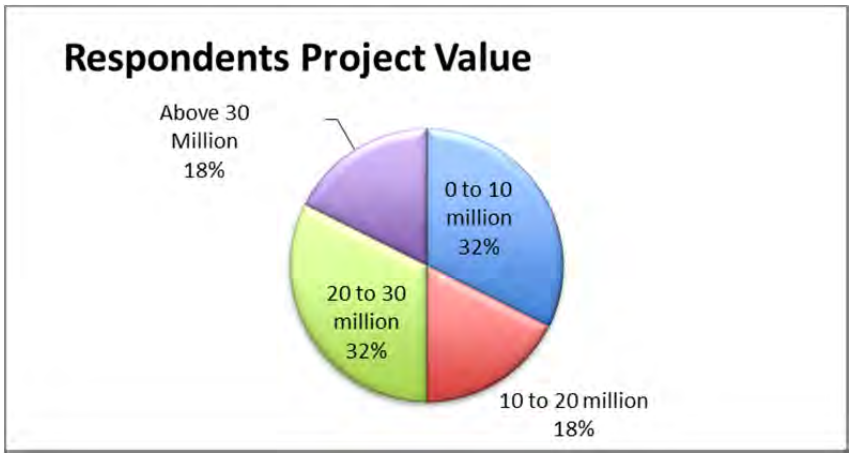


Figure 4.6 Respondents' Value of the Projects

The above findings provide a clear indication that the respondents are highly educated and bring a wide range of experiences and skill to the work environment. It is also very evident that the respondents are a matured workforce indicating the drive to succeed and make a difference in the workplace. The next section deals specifically with the project management deliverables.

4.3 Data Analysis and Interpretation of Project Management Deliverables (Section B)

In section B of the questionnaire, the researcher identified various factors that affect project performance and delivery in the existing practice. The impact and level of importance of these factors on project delivery were quantified. The questions were designed to indicate to the researcher the problems the project manager is likely to encounter in the execution phase of the project. These dynamics have the tendency to trigger many delays in the project process thus affecting overall project delivery.

The respondents were requested to rank the factors, by means of a Likert scale from 1 to 5, as either Very Low (1) or Low (2) or Average (3) or High (4) or Very High (5). According to the rankings as completed by the respondents, the following expresses the main factors that impact time, cost, quality and scope of work. Table 4.1 exhibits the factors that impact the project in relation to the time aspect.

Table 4.1 The Frequency of Factors that Impact Project Time

Factors Impacting the project Performance	Frequency in relation to Time
Rework due to poor construction	58%
Inadequate details in the design	56%
Discrepancies/Mistakes in the design package	50%
Insufficient information compiled during survey and design	50%
Variation orders during construction	50%
Delay in material requirements	47%
Inadequate planning during initiation of the project	47%
Poor / Ineffective project scheduling	44%
Poor qualification of project staff / Lack of skill	44%
Change in material type during construction	43%
Low productivity	43%
Improper construction methods	42%
Unskilled workforce	42%
Weak communication and coordination by project staff	42%
Material damages, whilst material is needed.	37%
Site uncertainties	37%
Complex project design	33%
Difficulties in financing the project/s	31%
Inadequate use of available technologies	31%
Poor site management	31%

From the above Table 4.1 the frequency factors that are greater than 40% show the factors that have the most impact on the project duration. These factors are likely to cause delay in delivering the project as per the time schedule. From the list of 20 factors, 14 factors have the greatest impact. The likelihood of these factors repeating in subsequent projects is high.

Table 4.2 The Frequency of Factors that Impact Project Cost

No	**Factors Impacting the project Performance**	**Frequency in relation to Cost**
1	Rework due to poor construction	69%
2	Discrepancies/Mistakes in the design package	58%
3	Difficulties in financing the project/s	56%
4	Inadequate planning during initiation of the project	56%
5	Material damages, whilst material is needed.	53%
6	Delay in material requirements	50%
7	Variation orders during construction	49%
8	Inadequate details in the design	47%
9	Poor qualification of project staff / Lack of skill	47%
10	Poor site management	46%
11	Change in material type during construction	44%
12	Insufficient information compiled during survey and design	44%
13	Site uncertainties	43%
14	Low productivity	42%
15	Unskilled workforce	42%
16	Complex project design	39%
17	Improper construction methods	37%
18	Weak communication and coordination by project staff	33%
19	Poor / Ineffective project scheduling	31%
20	Inadequate use of available technologies	31%

From the above Table 4.2 the frequency factors that are greater than 40% show the factors that have the most impact on the project cost. These factors are likely to cause delay in delivering the project within the allocated costs. From the list of 20 factors, 15 factors have the greatest impact. The likelihood of these factors repeating in subsequent projects is high.

Table 4.3 The Frequency of Factors that Impact Project Quality

No	**Factors Impacting the project Performance**	**Frequency in relation to Quality**
1	Rework due to poor construction	67%
2	Unskilled workforce	67%
3	Discrepancies/Mistakes in the design package	64%
4	Inadequate details in the design	57%
5	Poor qualification of project staff / Lack of skill	54%
6	Improper construction methods	53%
7	Delay in material requirements	46%
8	Insufficient information compiled during survey and design	44%
9	Change in material type during construction	43%
10	Site uncertainties	42%
11	Poor site management	41%
12	Complex project design	40%
13	Material damages, whilst material is needed.	38%
14	Weak communication and coordination by project staff	37%
15	Inadequate planning during initiation of the project	35%
16	Inadequate use of available technologies	35%
17	Poor / Ineffective project scheduling	35%
18	Variation orders during construction	33%
19	Difficulties in financing the project/s	31%
20	Low productivity	31%

From the above Table 4.3 the frequency factors that are greater than 40% show the factors that have the most impact on the quality of the project. These factors are likely to cause delay in delivering the project according to the predetermined quality specifications. From the list of 20 factors, 11 factors have the greatest impact. The likelihood of these factors repeating in subsequent projects is high.

Table 4.4 The Frequency of Factors that Impact Project Scope

No	Factors Impacting the project Performance	Frequency in relation to Scope
1	Inadequate details in the design	63%
2	Discrepancies/Mistakes in the design package	61%
3	Inadequate planning during initiation of the project	60%
4	Insufficient information compiled during survey and design	60%
5	Complex project design	56%
6	Rework due to poor construction	54%
7	Variation orders during construction	44%
8	Unskilled workforce	44%
9	Change in material type during construction	42%
10	Delay in material requirements	42%
11	Improper construction methods	41%
12	Low productivity	41%
13	Site uncertainties	40%
14	Material damages, whilst material is needed.	38%
15	Weak communication and coordination by project staff	38%
16	Poor qualification of project staff / Lack of skill	37%
17	Poor site management	35%
18	Inadequate use of available technologies	34%
19	Poor / Ineffective project scheduling	31%
20	Difficulties in financing the project/s	29%

From the above Table 4.4 the frequency factors that are greater than 40% show the factors that have the most impact on the scope of the project. These factors are likely to cause delay in delivering the project within the scope as defined by the project sponsor. From the list of 20 factors, 12 factors have the greatest impact. The likelihood of these factors repeating in subsequent projects is high.

4.3.1 Factors affecting the Time Deliverable of Project Management

The key factors affecting the time deliverable are as illustrated in Figure 4.7, which are based on the frequency of occurrence, discussed above which is 13 out of 20 factors. It is apparent from the results that reworks due to poor construction are the major factors affecting time, followed by inadequate details in the design. Variation orders during construction, insufficient information compiled during survey and mistakes in the design also contribute to the time deliverable. Delay in material requirements and inadequate planning during initiation" contribute 47% to time. Other key contributors are poor qualification of project

staff, ineffective scheduling, low productivity, changes in material type during construction, unskilled workforce, weak communication and coordination of project staff and improper construction methods.

It is evident from the research results that many factors can have a detrimental effect on the time principle in project management. It is therefore critical that 80% of the time is spent planning the project to alleviate any deviations likely to extend the project duration. As indicated in the literature review change in one principle is extremely likely to affect one or two of the project management principles.

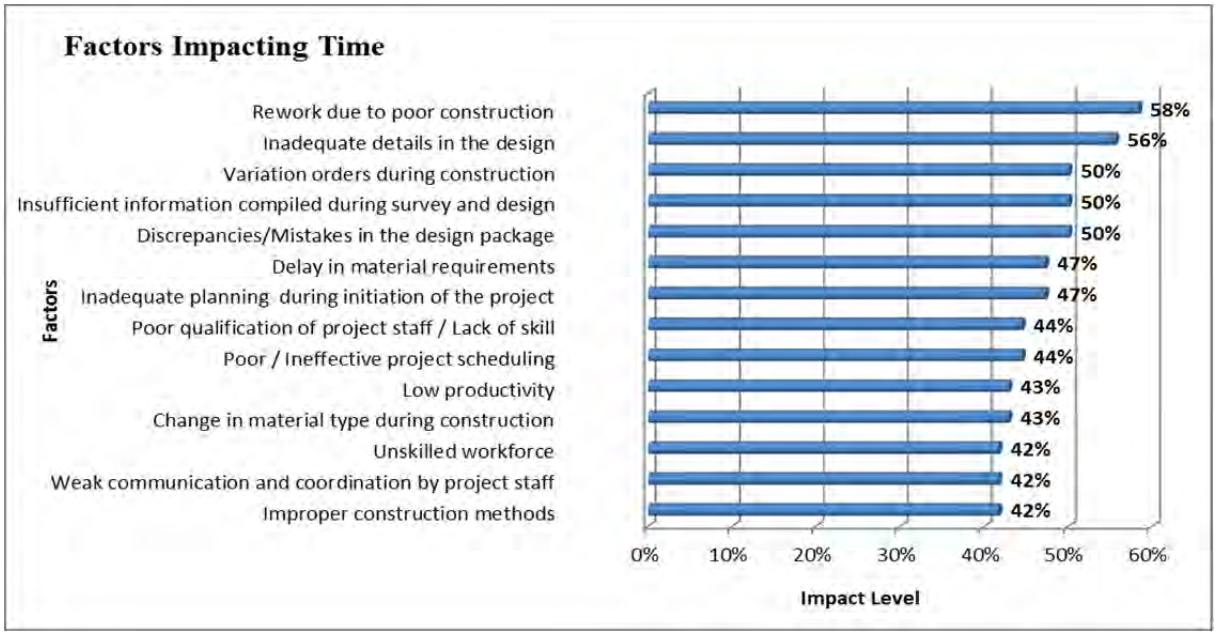


Figure 4.7 Key Factors Influencing the Time Deliverable

4.3.2 Factors Impacting the Cost Deliverable of Project Management

The key factors affecting the cost deliverable are as illustrated in Figure 4.8, which are based on the frequency of occurrence, discussed above which is 15 out of the 20 factors. It is evident from the results that the major factors affecting project costs are reworks due to poor construction. This is followed by mistakes in the design package. Difficulties in financing the project and inadequate planning during initiation of the projects impact project costs 58% of the time. Other mitigating factors are material damages, delay in material requirements, variation orders during construction, poor qualification of project staff, inadequate details in the design, poor site management, change in material type during construction, insufficient

information compiled during survey and design, site uncertainties, unskilled workforce and low productivity.

It is evident from the literature review that cost plays a major role in projects and many organisations are looking for cheaper ways in which to execute projects.

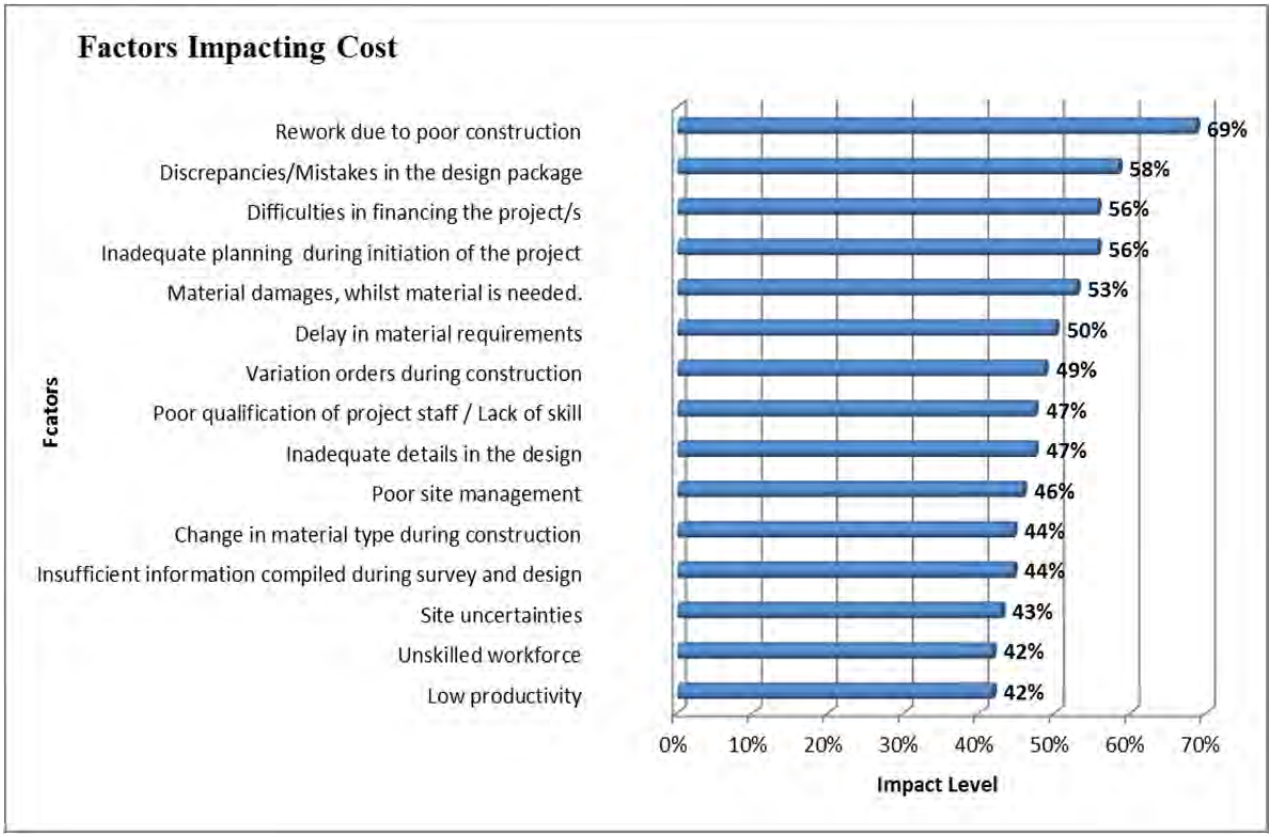


Figure 4.8 Key Factors Affecting the Cost Deliverable

4.3.3 Factors Impacting the Quality Deliverable of Project Management

The key factors affecting the cost deliverable are as illustrated in Figure 4.9, which are based on the frequency of occurrence, discussed above which is 12 out of the 20 factors. The major contributors to quality are unskilled workforce and rework due to poor construction. Discrepancies in the design package are also an important contributor to the quality component. The other contributors are inadequate details in the design, poor qualification of project staff, improper construction methods, delay in material requirements, insufficient information compiled during survey and design, change in material type during construction, site uncertainties, poor site management and to some degree the complexity of the project design.

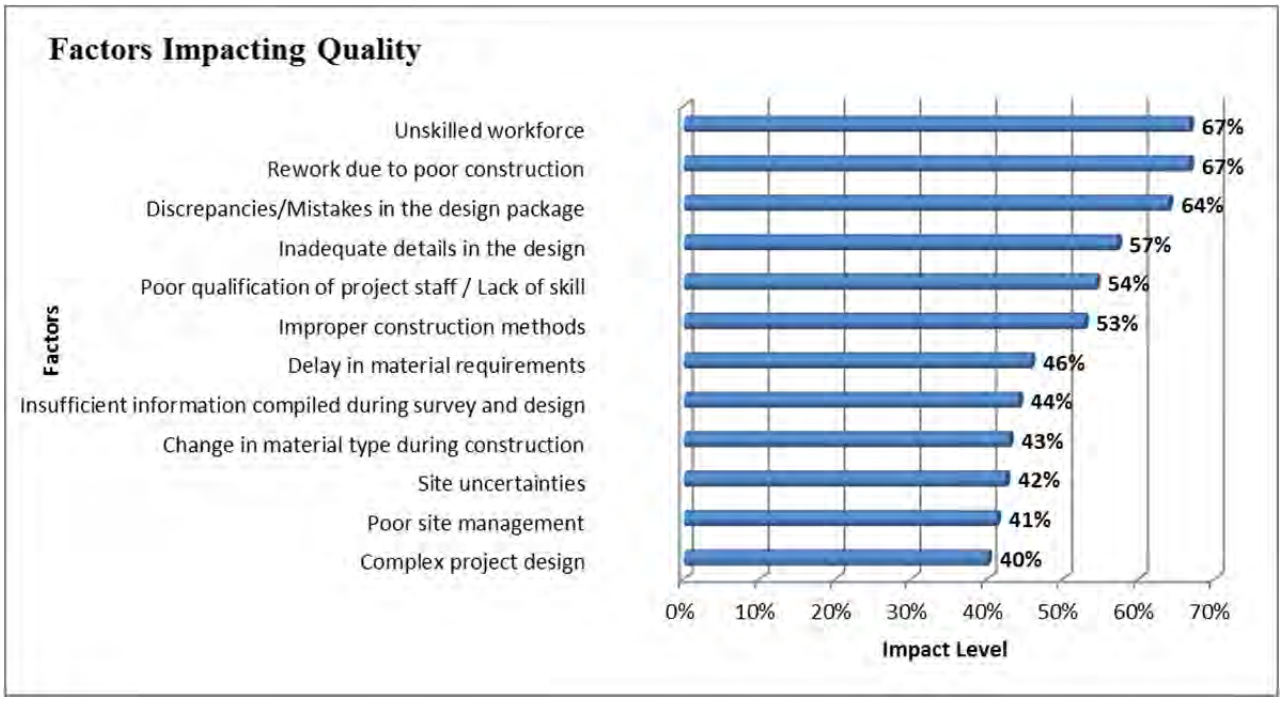


Figure 4.9 Key Factors Affecting the Quality Deliverable

4.3.4 Factors Impacting the Scope of Work Deliverable of Project Management

The key factors affecting the cost deliverable are as illustrated in Figure 4.10 which are based on the frequency of occurrence, discussed above which are 12 out of the 20 factors. The major factors contributing to the scope of work are inadequate details in the design, mistakes in the design package, insufficient information compiled during the survey and design, inadequate planning during initiation of the project, complex project design and rework due to poor consstrcution. The other qualifying factors are variation orders during construction, unskilled workforce, change in material type during construction, delay in material requirmenet, low productivity, improper construction methods and site uncertainties.

It is evident from the research results that any change or modificaiton to the project in the initial stages will have a huge impact on the project scope. Defining the project scope at the pre planning stage is critical as the scope is the end result of the project. If the project scope is not clearly defined then this will to lead to scope expansion over time which will ultimately affect time, cost and quality.

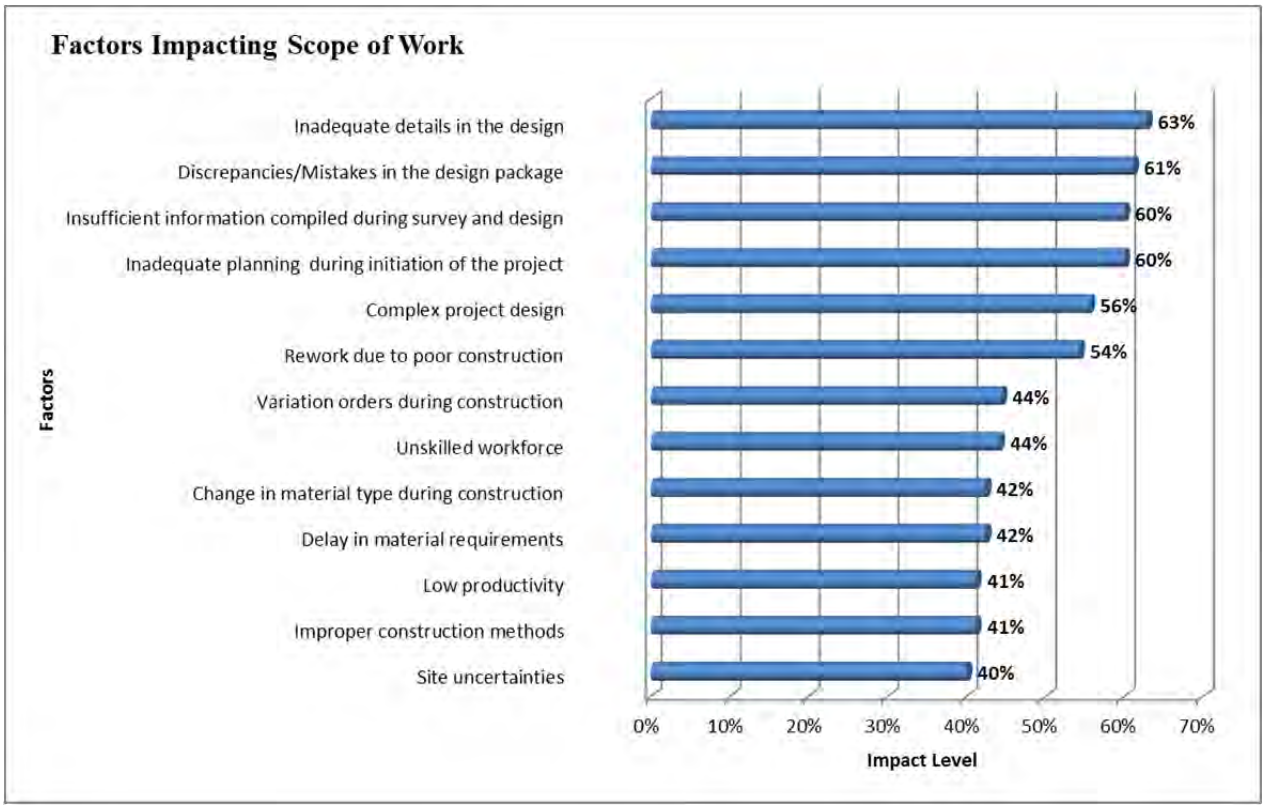


Figure 4.10 Key Factors Affecting the Scope of Work Deliverable

The respondents were asked to rate the factor that drives the project they manage as illustrated in Figure 4.11. According to the results, time is the most important driver followed by cost, then quality and lastly scope of work.

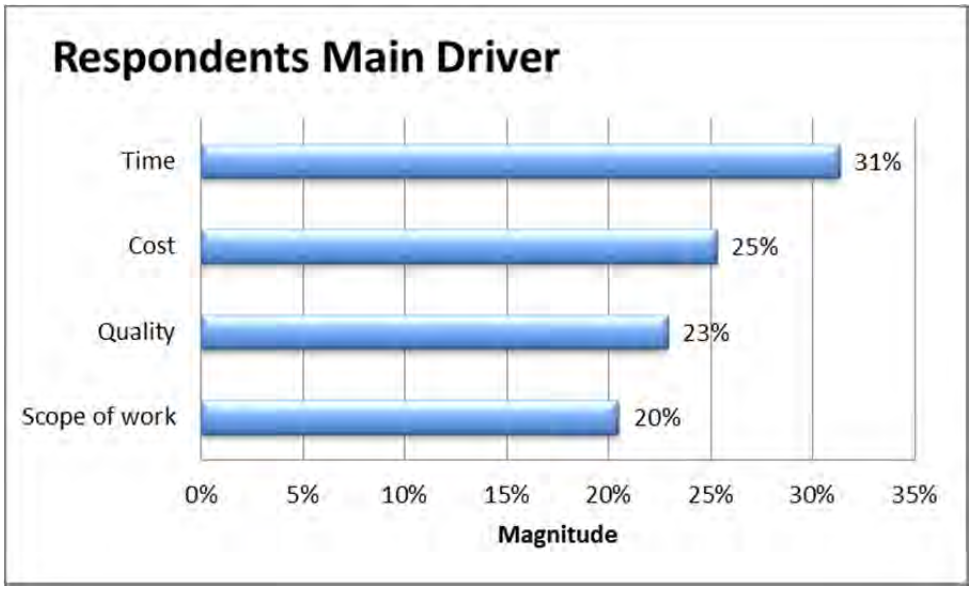


Figure 4.11 The Respondents' Main Project Driver

The following Figures 4.12 and Figure 4.13 illustrate the respondents' view on corrective action taken on projects. It is apparent from the research results that the majority of the respondents will endeavor to take corrective measures if there are deviations from the planned project schedule. Only a minor 3% indicated that no corrective action would be taken on the project.

The type of measures taken range from mitigating delays to considering different types of materials to be used. Approximately 20% will try to alleviate project delays, whilst 10% will look into different types of materials that can be substituted. 17% will consider multi-tasking the labour force in order to maintain time, cost, quality, and another 11% will review alternative designs as a mitigation strategy. 16% will try the pull approach by reducing inventory on hand to minimize project costs. 15% of the respondents will review minimizing wastes as a method to contain costs and lastly 12% will look into reducing contract labour.

Figure 4.12 Respondents' View on Corrective Measures

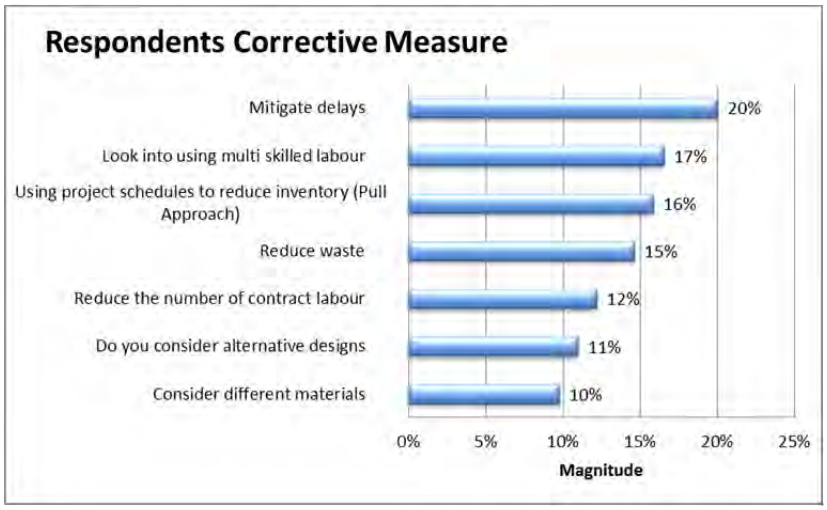


Figure 4.13 Respondents' Corrective Actions

Lastly Figure 4.14 provides indication of the respondents' view on projet management as a whole. 73% of the respondents indicated that project management is reactive in nature, whilst 27% believed that it is not reactive in nature.

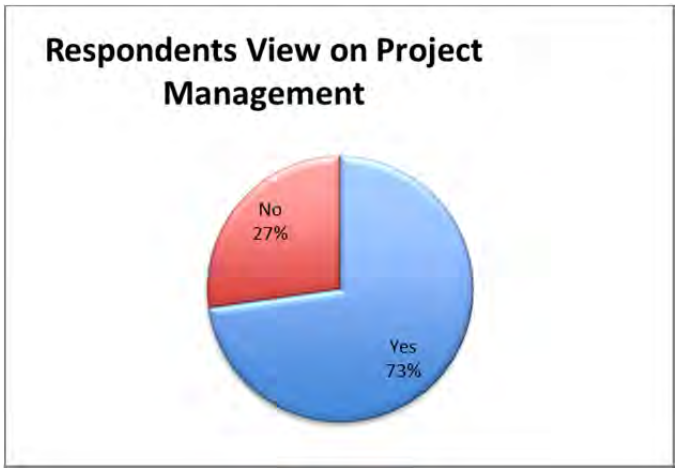


Figure 4.14 Respondents' View on Project Management

The research results indciate that project management is not a simple process but is an integrative and iterative process. The traditional project management principles depend more on upfront planning before the project can be implemented. The research indciates that many factors can impact time, cost and quality to varying degrees. Hence, the project manager needs to have a high vision of certainty in order for the project plans to be effective and to be able to deliver the project according to customer expectations and within the time, cost and quality constraint.

4.4 Data Analysis and Interpretation of Lean Principles (Section C)

This section of the qestionnaire was structured to elicit knowledge and awareness of lean principles. A Likert measurement was used, that ranged from Very Low (1), "Low (2), Average (3), High (4) and Very High (5). The Figure 4.16 and Figure 4.17 illustrates the potential to introduce new technology and the awareness of lean technology in the current environment.

As shown in Figure 4.15 it seems that 20% of the respondents believe that the potential to introduce new approaches is very low and 11% believe that there is just a low chance of this happening. However 33% deem that there is a possibility of introducing new technology, 17% think that there is a a high liklihood of this happening and 19% reason that the probability is very high.

It is very evident from the results above that 31% believe that the prospect of the company introducing a new method of working is highly improbable, whilst only 69% believe that an opportunity does exist.

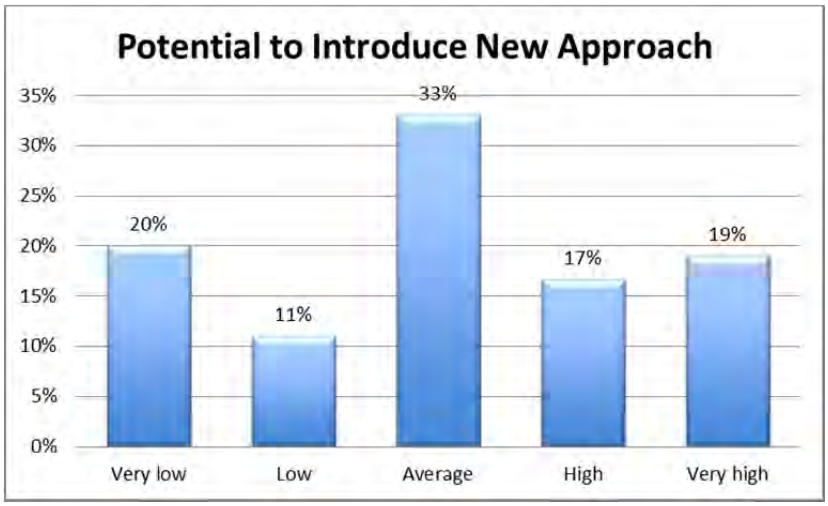


Figure 4.15 Potential to Introduce New Approach

The Figure 4.16 below shows the respondents' awareness and knowledge about lean principles. The results indicate that 57% have a very low understanding and awareness of lean principles and 26% have a low awareness. 11% of the resopondents have an average awareness of lean, 6% have a high knowledge of lean principles, whilst 0% have no knowledge or awareness.

The results are quite clear: about 83% of the respondents have little or no knowlegde about lean principles, whilst a minor 17% have some knowledge. This is indicative of the fact that the company will need to instill awareness and training if they plan to implement new technologies.

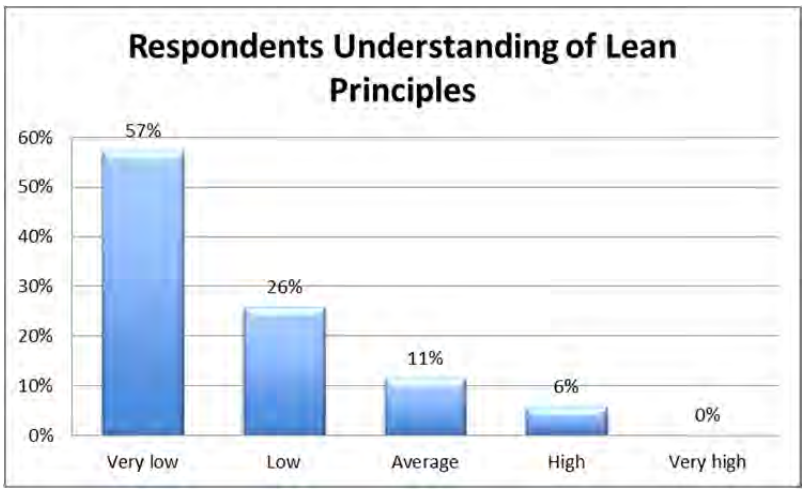


Figure 4.16 Respondents' Understanding of Lean Principles

Section C of the questionnaire included three questions (questions 3, 4 and 5) that specifically measured the use of computer aided tools to manage the performance of projects. Figure 4.17 illustrates the the tools used by respondents with their relative efficiency levels. It is apparent that 37% of the respondents actually use MS Excel as the tool to meaure project performance, whilst the rest of the in-house systems such as ACNAC, SAP and PPM are used practically.

Overall the respondents have confidence in the systems being used to manage and improve overall project performance.

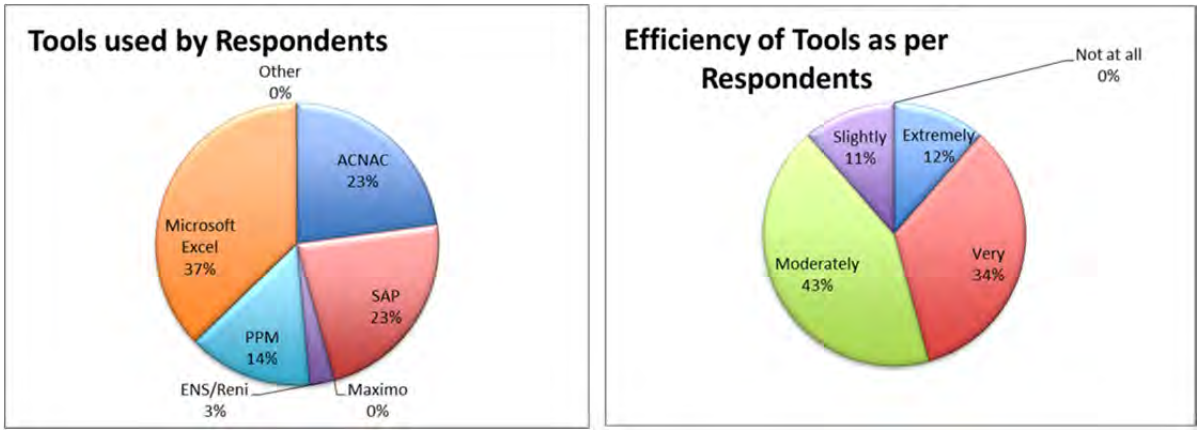


Figure 4.17 Efficiency of Tools used by Respondents

Question seven of the questionnaire dealt with the six lean principles as identified in the literature review. The objective was to ascertain the applicability of using lean principles in a project environment. The lean principles were measured against the Likert scale from Very Low (1), Low (2), Average (3), High (4) to Very High (5). In addition the mean score for each principle was calaculated as an average of the scores of each point of the total respondents who took part in the survey.

4.5 Reduction in Waste

Figure 4.18 represents each respondent's rating on waste reduction in the Project Management Department of Eskom KZN operating unit. The researcher can conclude based on the results, that the employees need to be cognizant of quantifying unproductive labour as 36% of the respondents believe that employees have low or very low awareness. A further 36% have an average awareness of unproductive labour in the project. This indicates that more attention needs to be made in this area as unproductive labour has a huge cost impact on

the project. More awareness needs to be created around material waste as 55% of the respondents, more than half of the rspondents, have a low or very low interest reducing material waste. 58% of the respondents believe that team members are not fully utlised, hence this is an area that can be improved. 63% of the respondents have indicated that unnecessary material movements are avoidable. More focus should be given to waste elimination methods as 47% of the repsondents have a low awareness and 15% have a very low awareness. The spotlight should be on the level material waste at the project site, as 76% of the respondents indicated a low to very low awareness. Lastly there is concern for reducing non value adding activities. Overall attention needs to be a high prioirity in the area of waste reduction as awareness and knowledge are low on average. Figure 4.19 reveals the mean score for each of the waste reduction principles for the 37 respondents.

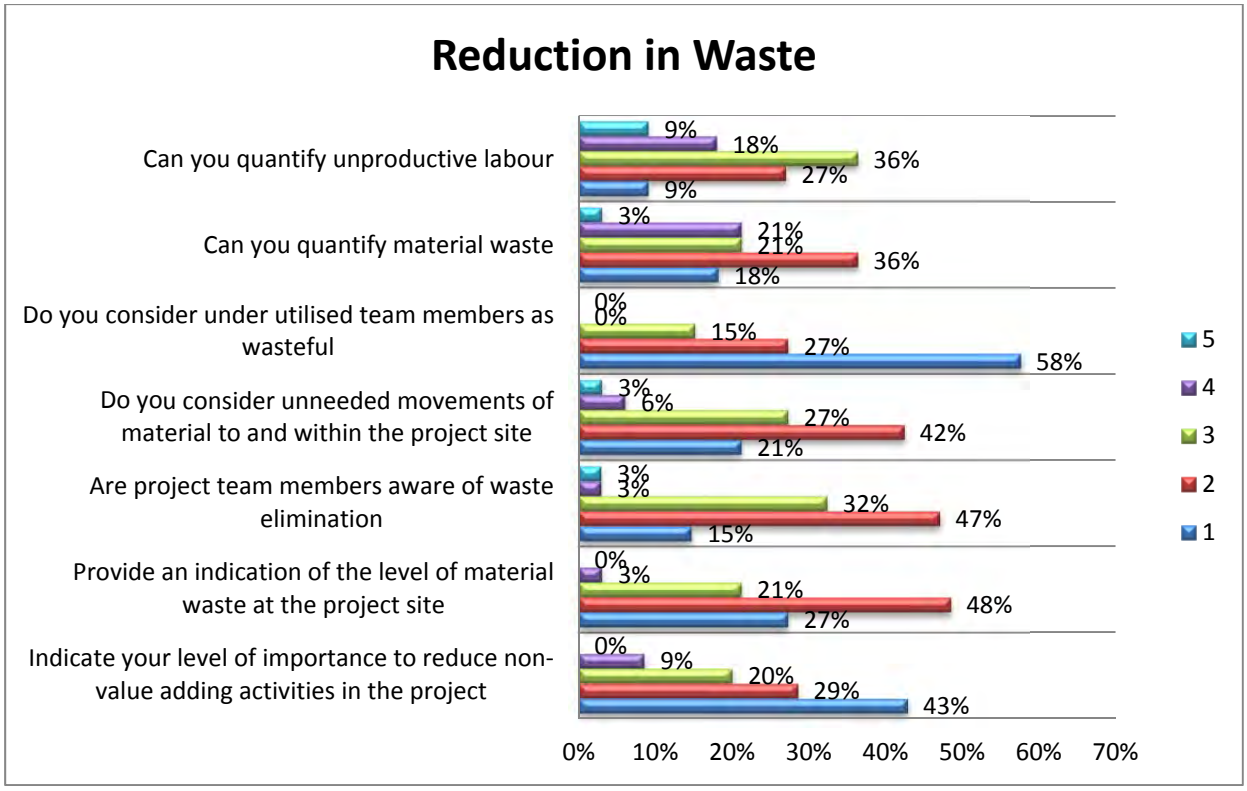


Figure 4.18 Reduction in Waste

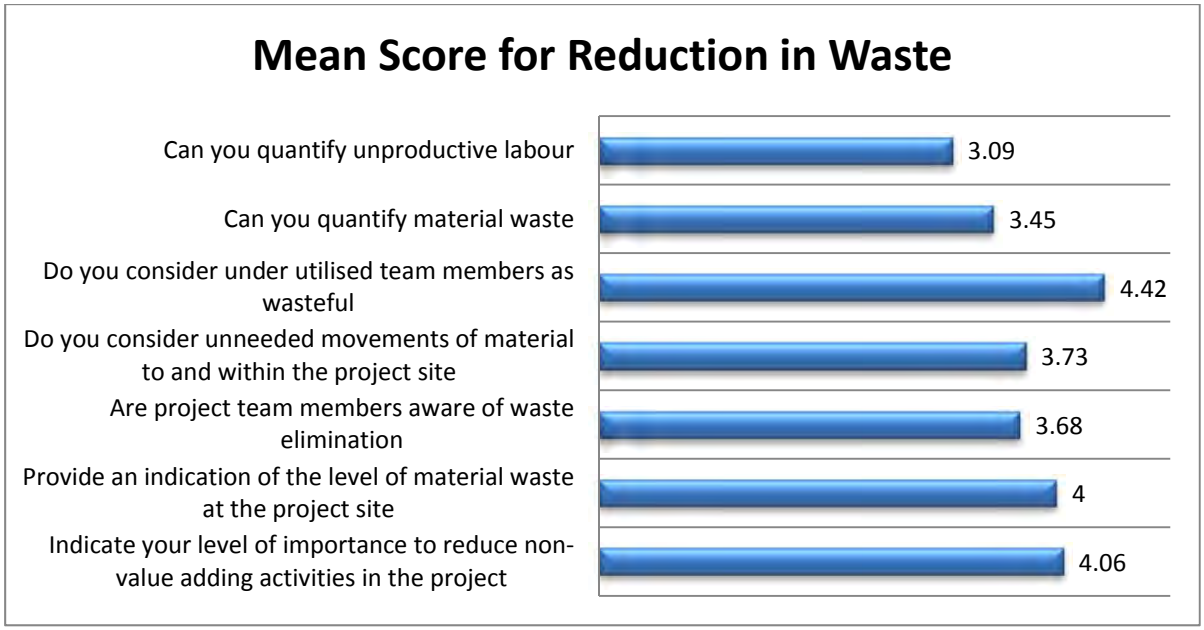


Figure 4.19 Mean Score for Reduction in Waste

4.6 Reduction in Variability

Figure 4.20 represents each respondent's rating on reduction in variability in the Project Management Department of Eskom KZN operating unit. From the results as depicted in Figure 4.21 although the design and construction process seem fairly standardised, some attention needs to be placed on standardisation as 21% of the respondents demonstrate a low to very low awareness for both principles. Communication processes need to be improved as respondents indicated a low to very low awareness. 46% of the respondents do review the design, however a combined 54% of the respondents range from reviewing to not reviewing the design before construction starts. The researcher can thus conclude that there is strong potential for implementing the lean principles in the project environment. Figure 4.22 reveals the mean score for each of the reduction in variability principles for the 37 respondents.

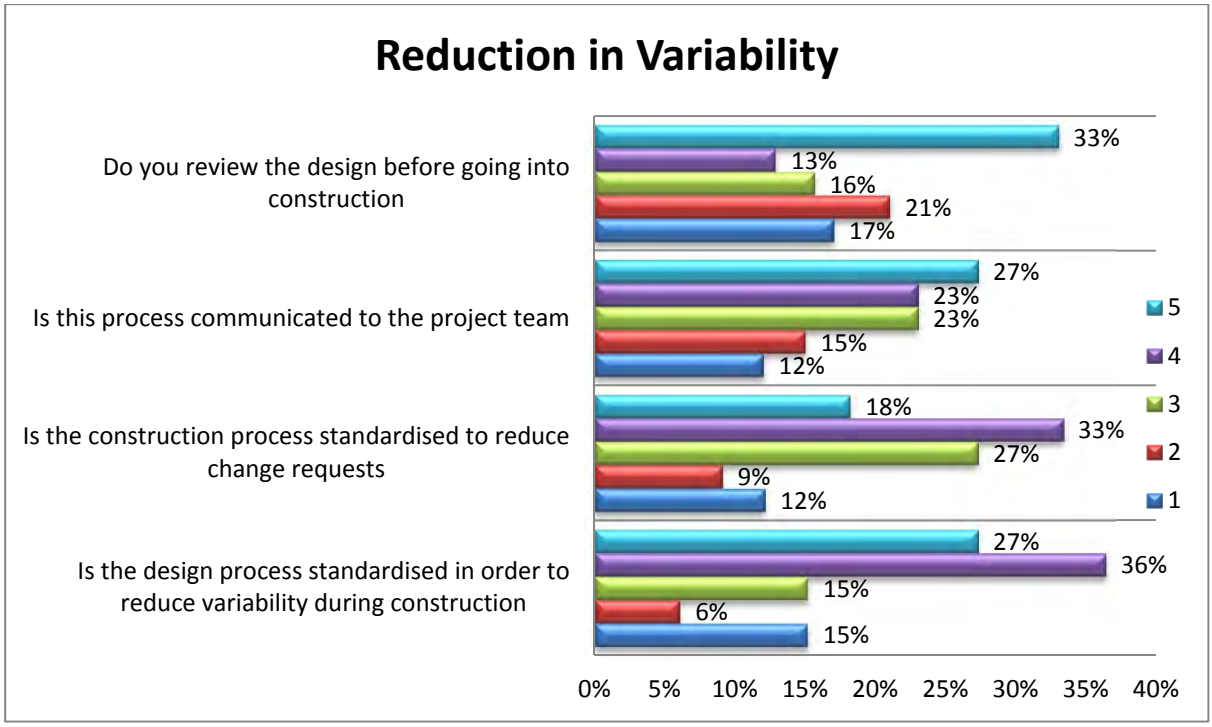


Figure 4.20 Reduction in Variability

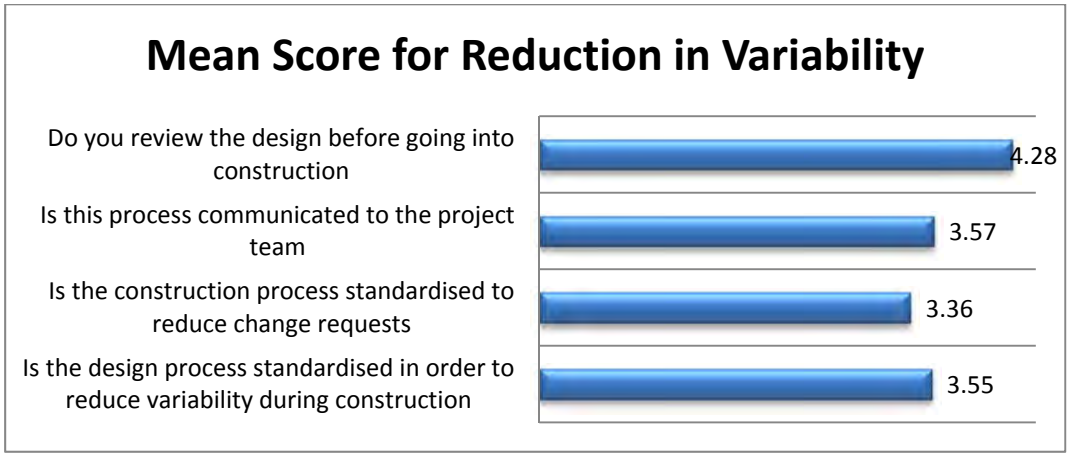


Figure 4.21 Mean Scores for the Reduction inVariability

4.7 Flow Variability

Figure 4.22 represents each respondent's rating on flow variability in the Project Management Department of Eskom KZN operating unit. From the results as depicted in Figure 4.22 it can be deduced that project schedules to a large extent are being utlised to improve process work flow, as approximately 70% of the respondents make use of schedules. Communication tools are utlized by more than 64% of the respondents. An area that needs improvement is just-in-time materials management, as 60% of the respondents indicated that

this process is not exercised to its full potential. The concept of work flexibity by using a multi skilled labour force can be improved. The process work flow used to manage project resources seems to be moderate, however there is room for improvement. Figure 4.23 reveals the mean score for each of the flow variability principles for the 37 respondents.

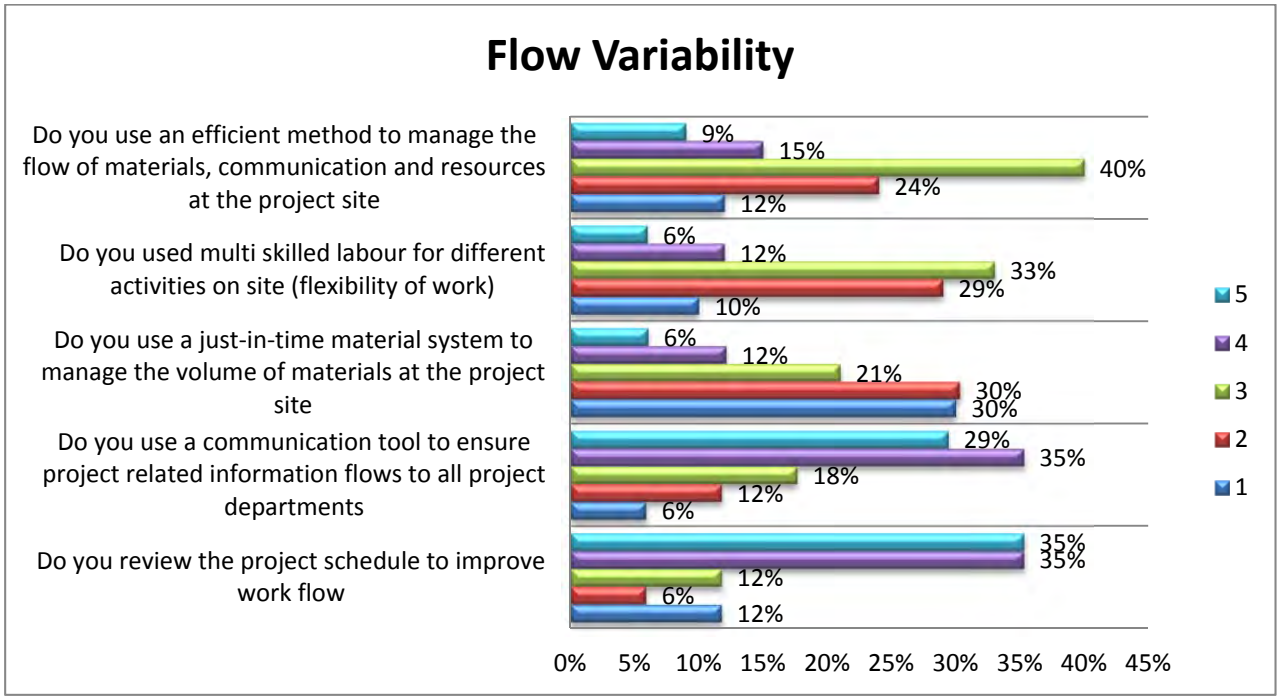


Figure 4.22 Flow Variability

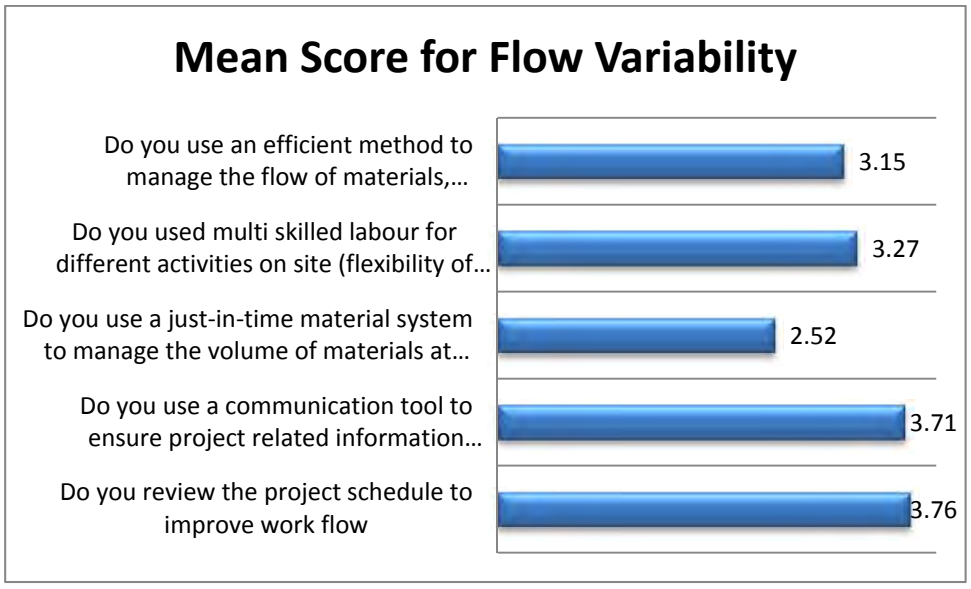


Figure 4.23 Mean Score for Flow Variability

4.8 Process Variability

Figure 4.24 represents each respondent's rating on process variability in the Project Management Department of Eskom KZN operating unit. As depicted in Figure 4.24 the current pocess adopted at the company seem to be working, however improvements can be made in the morning meetings that are held with the project team, as 12% of the respondents are nearly not effecting this process. Figure 4.25 reveals the mean score for each of the process variability principles for the 37 respondents.

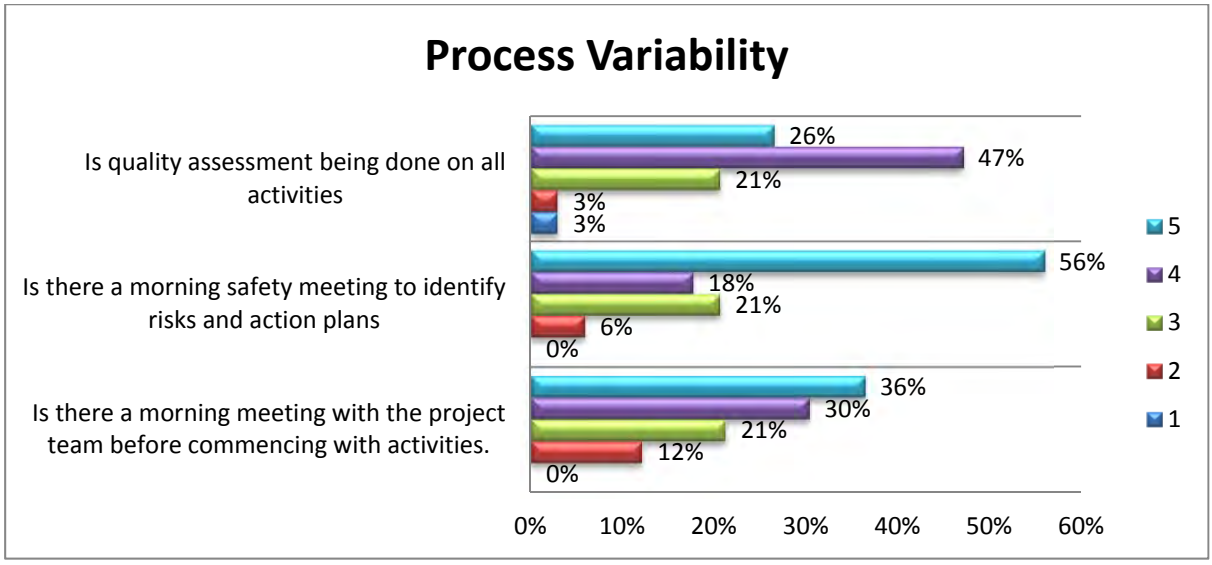


Figure 4.24 Process Variability

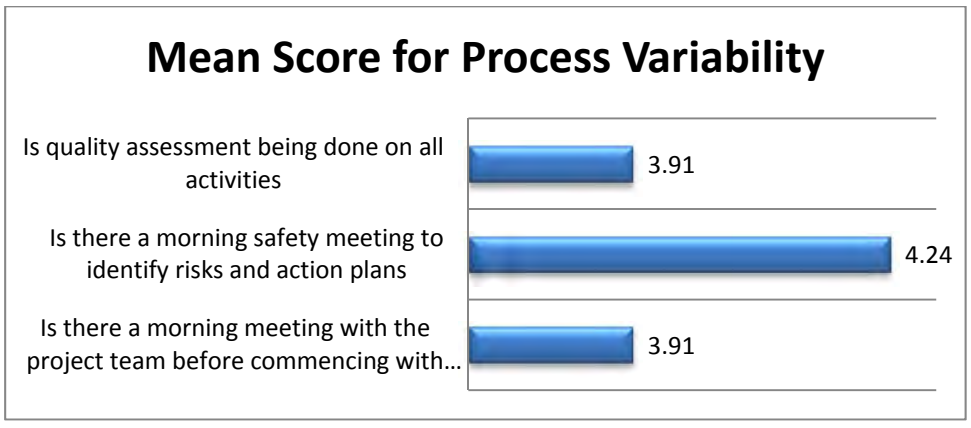


Figure 4 25 Mean Score for Process Variability

4.9 Increase Transparency

Figure 4.26 represents each respondent's rating on increase transparency in the Project Management Department of Eskom KZN operating unit. It can be established that 81% of the

respondents have encompassed housekeeping in their project sites. It is evident that clear work instructions are given to the project team, with only a minor 3% of the respondents not adhering to this method. Seemingly, 79% of the respondents are not fully ultising visual management tools at their project sites. There are only a few projects which are making use of safety signs only which is about 21% of the respondents. Therefore this is an area for improvement. Conversely more than 72% of the respondents are using communication tools to transmit project progress and project risks. Figure 4.27 reveals the mean score for each of the increase transparency principles for the 37 respondents.

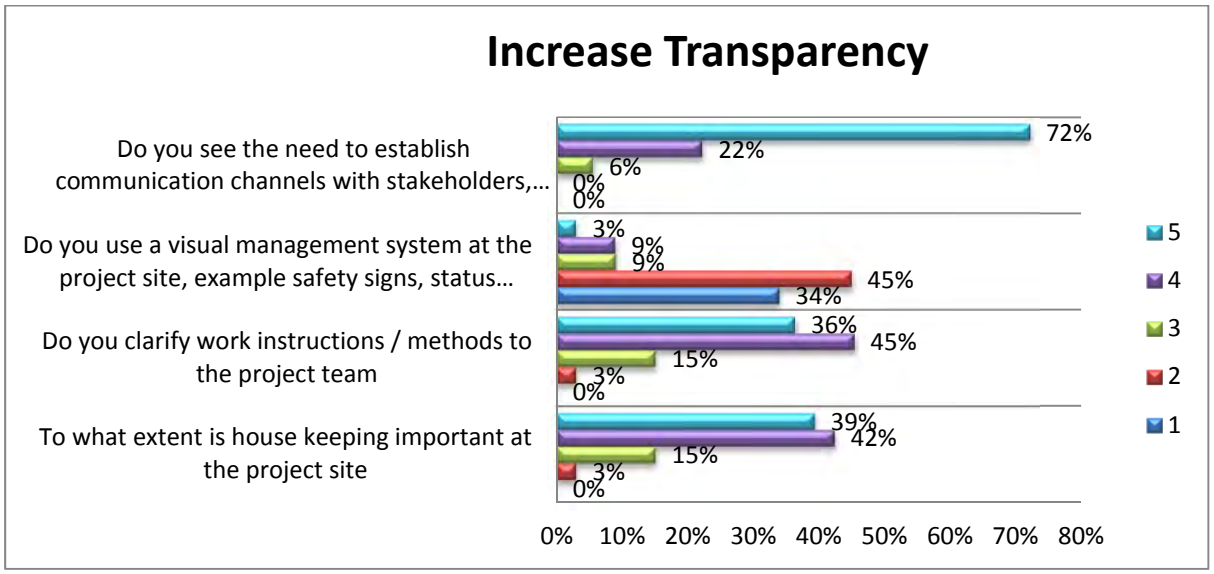


Figure 4.26 Increase Transparency

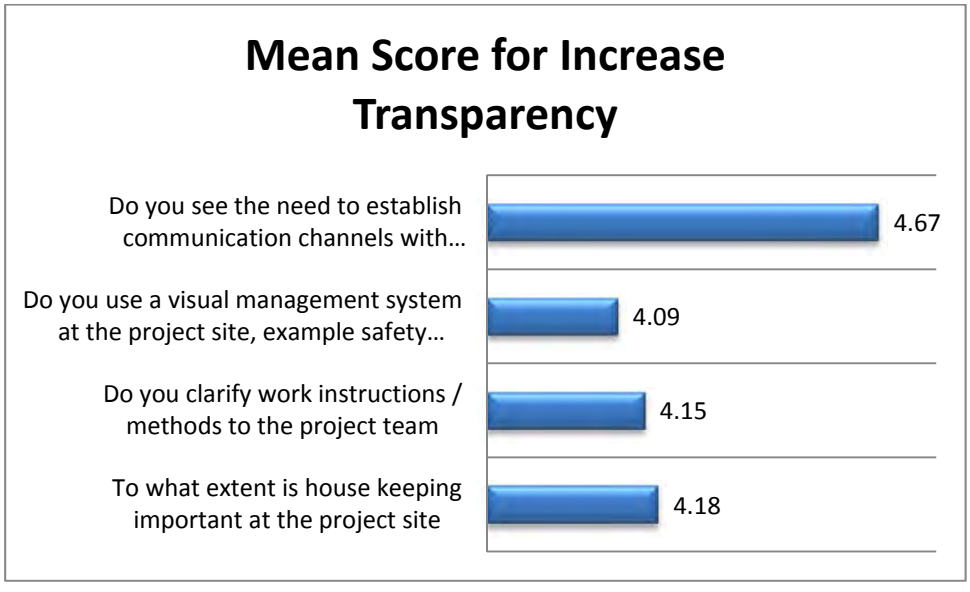


Figure 4.27 Mean Score for Increase Transparency

4.10 Continuous improvement

Figure 4.28 represents each respondent's rating on continuous improvement in the Project Management Department of Eskom KZN operating unit. It is apparent from the research results that all of the methods asociated with continuous improvement can be utilised in the project environment. However there is room for improvement in proactive measures and customer feedback. Figure 4.29 reveals the mean score for each of the continuous improvement principles for the 37 respondents.

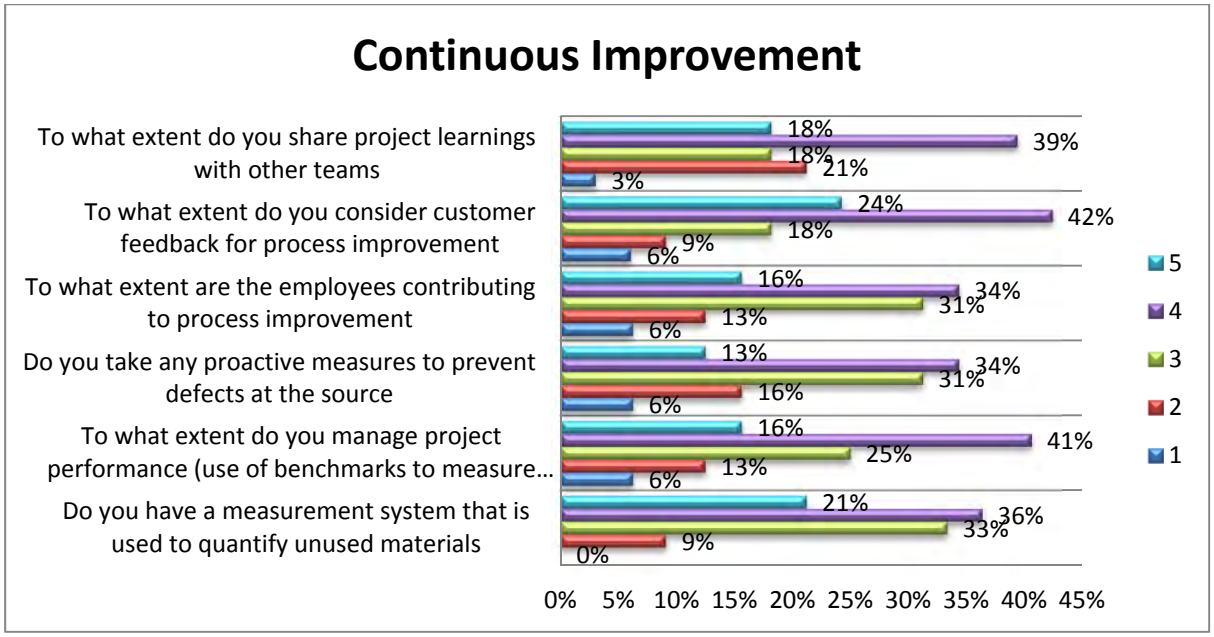


Figure 4.28 Continuous Improvement

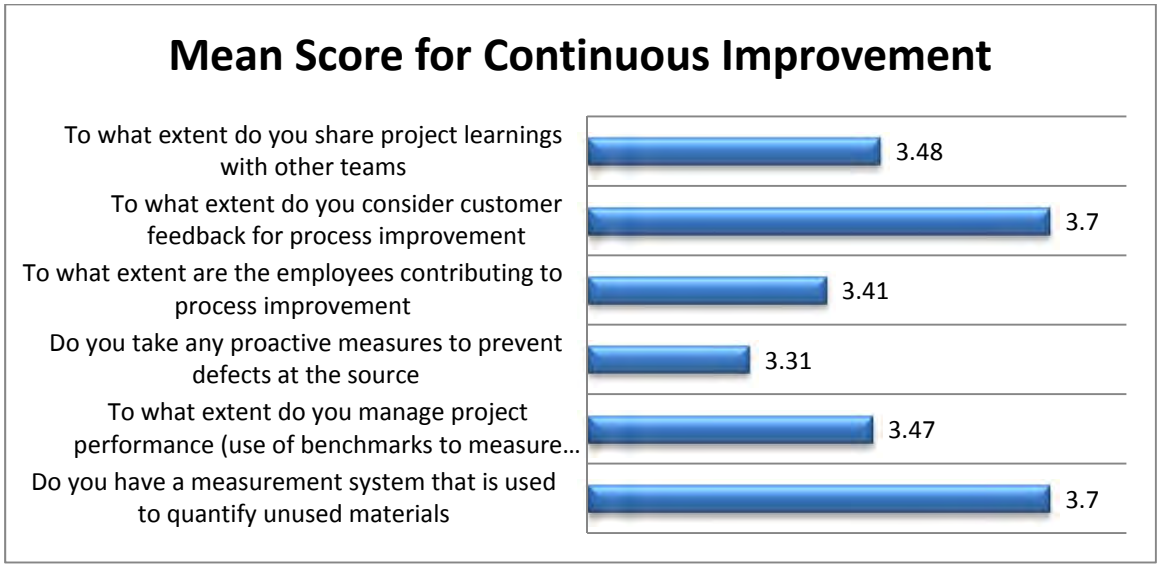


Figure 4.29 Mean Score for Continuous Improvement

The Figure 4.30 below illustrates the respondents' ratings on using lean principles as a tool to measure project peformance and to improve the delivery of projects. 94% of the respondents agreed that lean principles can be used as a tool to measure project performance and 94% agreed that lean is a proactive tool rather than a reactive tool.

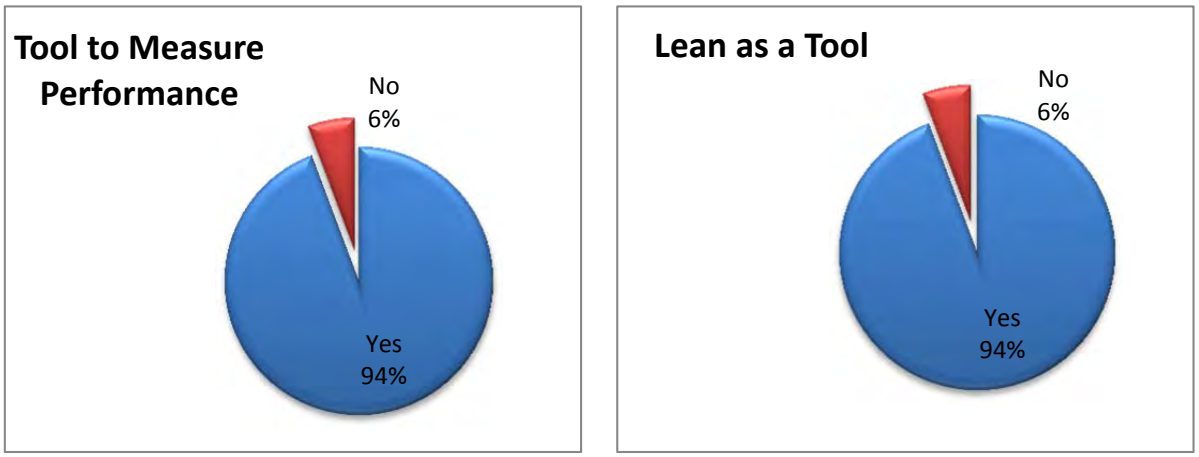


Figure 4.30 Lean Principles as a Tool for Projects

4.11 Questionnaire Results on Lean Principles

4.11.1 Respondents Awareness of Lean Principles

The research results revealed that 83% of the respondents are unfamiliar with lean principles, whilst 17%% of the respondents are reasonably aware of them. The main objective of this study was to identify if lean principles can be used in projects to increase performance. The next section investigates which lean principles can be effectively implemented in the project environment.

4.11.2 Implementation of Lean Principles

The Tables 4.2 and 4.3 depict all the lean principles with their relative mean score. The score of 4.01 and above is an indicator for the level of implementation of these techniques in Eskom's project management environmemt within the KZN Operating Unit. Any score less than 4.0 is a clear indicator of lean methods that are either not efficiently implemented or not entirely implemented in the project environment.

Table 4.2 depicts all the lean principles with a mean score of greater than 4.0. The score is an excellent indicator for the degree of implementation of these methods in the project

environment. These processes are just about fully implemented and are effective; and with added effort their productivity will be augmented.

Table 4.5 Lean Principles Implemented in the Project Environment

Scope	Lean Principle Implemented/Can be Improved	Mean Score
Reduction in waste	Indicate your level of importance to reduce non-value adding activities in the project	4.06
	Do you consider under utilised team members as wasteful	4.42
Reduction in variability	Do you review the design before going into construction	4.28
Process variability	Is there a morning safety meeting to identify risks and action plans	4.24
Increase transparency	To what extent is house keeping important at the project site	4.18
	Do you clarify work instructions / methods to the project team	4.15
	Do you use a visual management system at the project site, example safety signs, status boards, etc.	4.09
	Do you see the need to establish communication channels with stakeholders, engineers, contractors and customers	4.67

From the above Table 4.5 it is evident that the project management approach has incorporated some of the lean principles to deliver projects, however these factors will need to be reviewed to increase value. The table above provides a clear indication that managing wasteful activities is of high importance to the project team. There is ample evidence that variability is controlled to a ceertain degree, but there is room for improvement. Project co-ordination is a complex activity and being transparent with regards to the project site and communciation mediums will assist with minimising unnecessary acitiites.

Table 4.6 depicts all the lean principles with a mean score of 4.0 and less The score is an excellent indicator for the degree of implementation of these methods in the project environment. The score per principle indicates that the majority of the lean principles will need to be evaluated and assessed to determine applicability in the project environment.

Table 4.6 Lean Principles to be Implemented in the Project Environment

Scope	Lean Prinicple to be Effectivley Implemented	Mean Score
Reduction in waste	Provide an indication of the level of material waste at the project site	4.00
	Are project team members aware of waste elimination	3.68
	Do you consider unneeded movements of material to and within the project site	3.73
	Can you quantify material waste	3.45
	Can you quantify unproductive labour	3.09
Reduction in variability	Is the design process standardised in order to reduce variability during construction	3.55
	Is the construction process standardised to reduce change requests	3.36
	Is this process communicated to the project team	3.57
Flow variability	Do you review the project schedule to improve work flow	3.76
	Do you use a communication tool to ensure project related information flows to all project departments	3.71
	Do you use a just-in-time material system to manage the volume of materials at the project site	2.52
	Do you used multi skilled labour for different activities on site (flexibility of work)	3.27
	Do you use an efficient method to manage the flow of materials, communication and resources at the project site	3.15
Process variability	Is there a morning meeting with the project team before commencing with activities.	3.91
	Is quality assessment being done on all activities	3.91
Continuous improvement	Do you have a measurement system that is used to quantify unused materials	3.7
	To what extent do you manage project performance (use of benchmarks to measure performance)	3.47
	Do you take any proactive measures to prevent defects at the source	3.31
	To what extent are the employees contributing to process improvement	3.41
	To what extent do you consider customer feedback for process improvement	3.7
	To what extent do you share project learnings with other teams	3.48

From the above Table 4.6 it is evident that the project management approach will need to be reviewed to incorporate the lean principles to deliver projects. In relation to the 5 lean principles, it is clear that the project environment needs to be overhauled. With regards to elimination of waste, Eskom needs to implement processes at site that will minimse material movements and unproductive labour issues. Although Eskom does try to manage variability, it seems that more effort needs to be placed in standardising the work processes and ensuring that all team members are informed on worked procedures. Flow varibilty seems to be Eskom's weakest link. Eskom needs to view the project as a value tream in such a way that

bottlenecks are removed nd the process becomes more leaner. Proces variability will need some improvement in order to make the process lean. Continuous improvement means that Eskom will need to use benchmarks and responsibilty matrixes to assist with ongoing improvement. The project team need to share learnings from projects, to ensure mistakes are not repeated. The most important rule is to educate the project team as this will produce sucessful outcomes.

4.12 Concluding Remarks

From the above analysis and research findings, it is apparent that 94% of the respondents are in agreement that lean principles can be used to improve project delivery and performance. Simultaneously only 17% of the respondents are aware of the lean philosophy. Approximatley 92% of the respondents have more than 5 years working experience and are in a postion to implement new methods. Only 8% of the respondents have a low potential to implementing new methods.

The findings for the project management deliverables are based on frequency of occurrence. The research indicated for the time deliverable that 13 factors from the list of 20 have the greatest impact on the time aspect. The highest impact is on the cost aspect of the project. From the list of 20 factors, 15 factors impact project cost. With regard to quality and scope of work 12 factors each from the list of 20 impact the project quality and the project scope. Based on the research objectives the conventional project management methods are inadequate to deliver projects within time and cost and according to quality specifications. The research highlighted many non-value adding processes within the conventional method and if not reviewed there is a high probability of these non-value adding activities repeating in future projects.

The findings from the research relating to lean principles indicate that some of the lean principles have been effectively implemented in the execution of projects, that is those factors with a score of greater than 4.01. These principles, however can be reviewed to increase value. The findings also depict that there is an opportunity to review the factors with a mean score of less than 4.01. In summary the findings from the research indicte that lean principles are applicable in the project execution environment.

CHAPTER 5

RECOMMENATIONS AND CONCLUSIONS

5.1.Introduction

Chapter 5 presents the summary of the research study that was conducted. The researcher has drawn conclusions from the findings that were presented in chapter 4 as well as referencing the literature review in chapter 2. In addition, the researcher has re revisited the objectives of the study and provides conclusions and recommendations for future research.

5.2 Summary of Research Results

The objective of this study was to evaluate the applicability of lean principles in a project environment with the purpose of improving overall project delivery and performance. The study investigated areas of lean management to evaluate the appropriateness of the approach. The methodology used was based on the following foundation:

1. The literature review to ascertain the applicability of lean principles in the execution of projects.
2. The questionnaire was used as a tool to gather information relating to factors affecting the projects' performance and to measure the project team's awareness of lean principles.
3. An evaluation of the conventional project approach and its effect on project execution as being reactive in nature.

5.3 The Research Findings

The study identified three objectives:

Objective 1: To investigate the effectiveness of the conventional project management processes.

The factors listed below represent a higher frequency of occurrence with respect to time, cost and quality within the existing project management processes.

- Insufficient information compiled during survey and design
- Discrepancies/Mistakes in the design package

- Inadequate details in the design
- Change in material type during construction
- Delay in material requirements
- Rework due to poor construction
- Poor qualification of project staff / Lack of skill
- Unskilled workforce

The findings from the study concluded that there were a number of factors that influenced the delivery and performance of projects. The research indicated that 75% of the respondents believe the current processes are flawed and need reviewing. In essence, the lack of planning at the initial onset of the project is causing poor performance. Discrepancies in the design are leading to poor quality, which ultimately affects the duration and cost of the project. From Eskom's perspective the most significant factors affecting project performance are in the pre-planning stages of the project which are the initiation and planning phases as depicted in the literature review, as the results from the survey indicate that insufficient planning can lead to time and cost overruns and a poor quality product. The major factors affecting the project from the contractor perspective are construction reworks due to poor design or design reworks, which indirectly affects the contractor skill level. Thus, the workforce may not be unskilled but, due to the quality of the design the workforce may experience difficulties executing the design. These factors have a detrimental effect on the quality of the product and increase the time to completion.

The material changes during construction affect the overall time and cost for both Eskom and the contractor. The management of materials is a planned activity that includes placing the material order, delivery of the order, and handling to ensure the requirements are met. The detailed material schedule and co-ordination of the order are vital in ensuring material is available just-in-time. However, with design reworks and the quality of the designs, material planning is not possible as materials will not be available for use when needed. Consequently, this leads to low productivity at site as contractor resources are unable to continue with their construction plans. This has a direct impact on the cost element as resources will be paid for standing time and the costs to deliver the new materials will be at a premium price.

It is apparent that the majority of these factors is dependent on pre-planning before executing the project. Poorly trained project construction workers indicate that the contractor workforce is misaligned to Eskom's standards and procedures in terms of construction regulations.

Concerning the time aspect, the following factors showed a higher frequency of concurrence:

- Variation orders during construction,
- Inadequate planning during initiation of the project, and
- Low productivity.

Variation orders during construction are a common occurrence, as they entail amending the approved scope as a result of poor planning or due to a change in the schedule during construction which results in a reallocation of project resources. Furthermore, the complexity of the design will dictate the type of skill required and construction methods. The findings indicate that a lack of planning at the initial stages hinders the progress of the project, which impacts productivity. Inadequate planning leads to delays in achieving the project milestone as per the approved timelines. This involves additional costs and disruptions to work already underway, leading to time and cost overruns. “Non-value adding activities such as unplanned site meetings, travelling, and idle labour time arise whenever variation orders exist”. It is evident that planners and project designers need to be aware of the requirements of a project before concluding the design and requirements for executing a project.

The following factors are seen to be affecting cost and quality only in projects:

- Site uncertainties
- Poor site management
- Improper construction methods

The deficiencies in the conventional project methodology are the root cause for problems experienced during construction as pointed out in the literature review. Project management according to the PMBOK (2013) is failing as it depends on an inadequate understanding of the nature of project work. The conventional methods as defined are unable to provide predictable results (Howell and Lichtig, 2008). The findings from the survey also indicate the project management is reactive in nature. This is indicative of the fact that project variances are not prevented and corrective action is rather taken to rectify the variability in the design and construction of the project. The conventional method of managing projects is reliant on the performance of project activities according to the plan and not in relation to the management of activities (Howell and Koskela, 2000).

Considering the deficiencies in the conventional project methods, Eskom should consider reviewing the existing processes, as they are definitely not assisting the company in delivering projects in a cost efficient and timely manner.

Objective 2: To assess the areas where lean principles can be applied to the current project management process.

The findings from the study indicate the there is a 69% probability of introducing lean methods to deliver projects at Eskom. The balance of the population believes that this is not possible due to the rigid nature of the way in which projects are managed at Eskom. However, research has indicted that these methods are not sustainable and it is advisable to look into the lean philosophy. Lean project management has two focus areas, which are waste reduction and managing the workflow to add value. Implementing lean principles will result in cost savings due to improved productivity and project activity duration will be shortened by accelerating activities. In addition, by removing reworks and changing logic to allow concurrent activities, waste can be reduced. Lean principles lead to change in all aspects of project work. According to the findings of the study, 94% of the respondents conclude that lean tools can be used to influence project performance.

The research revealed that many of the lean factors with a mean score of less than 4.0 are not effectively being implemented in the current processes. In addition, those factors with a mean score of greater than 4.01 needs to be reworked so that they add value to the project related activities. Many renowned scholars have indicated various benefits of introducing lean principles to improve project performance. The potential benefits of using lean can lead to greater cost savings, a higher quality product and quicker completion time.

Objective 3: To identify non-value adding activities

The research findings highlighted many non-value adding activities:

- Just-in-time material process not used
- No method to quantify material waste
- No measurement system to quantify unused materials
- Quality assessment being done on all activities
- No standard method to manage material flow and resources
- Process to consider unneeded movements of material to and within the project site

- Limited use of benchmarks to measure performance
- No sharing of project learnings
- Unable to quantify unproductive labour
- Non-flexible work methods
- No standardized construction process to reduce change requests
- The design process is not standardized to reduce variability during construction
- Standard processes not communicated to project teams
- No standard to review the project schedule to improve work flow

Lean principles have always been linked with cost reduction, the elimination of waste, and just-in-time material delivery. In light of the challenges facing Eskom, it would be practical to implement a just-in-time process or the pull system. This means only the required materials are delivered to project sites as based on the construction plan per project. The construction plan would be based on project zones and as the project team moves along each zone, this would include materials being pulled by the system. The advantage of implementing just-in-time will reduce inventories to a lowest amount. In addition, it will minimize the effect of unneeded movements of material to and within the project site and in doing so reduce non-value adding activities. Just-in-time provides a standard method to manage material flow and resources and increases efficiencies at the project site as well as providing a measurement system to quantify unused materials. By incorporating the Kanban control process which makes use of a visual system to control the movement of materials at the project site and Eskom's warehouse this will alleviate the unnecessary material movements. Another benefit would include improvements in the quality of the construction work. The essential idea of just-in-time and lean systems is to empower the workers to make decisions and eliminate waste and non-value adding activities. However there are some drawbacks such as increased transportation costs, due to the frequent material deliveries that would be required and Eskom would not be able to roll out unexpected projects due to availability of materials. Just-in-time can be seen as a way of thinking, working and managing of activities at site to minimise non-value adding activities in the execution of projects.

Key performance indicator (KPI) can be used to combat the limited use of benchmarks to measure performance. This indicator will assist with measuring and tracking project performance against set targets. KPI is a strong tool and can influence employees' behaviour

thus they need to be designed carefully to ensure the development of preferred behavior. This metric connects the project team and assist in driving the team to a common goal whilst reminding the employee the importance of continuous behavior.

It is evident from the research that project learnings are not shared with relevant people in the project management field. The factor is pivotal and needs to be in the form of project reviews, which need to be presented at the closure of each project. Project resources to validate lessons learnt from each project and these learnings must be shared to ensure that common mistakes are not repeated and decisions taken that had a positive impact on the project are known. This activity will assist in eliminating wasteful activities.

The literature review referred to the lean product delivery system (LPDS) which focuses on planning and design stages of the project and the findings from the research indicate a gap in those phases. LPDS allows the project to be structured and to be managed as a value generating process. The process allows for the planners and designers to participate in the project at the early stages via cross-functional teams. Pull techniques are used to manage the information and material flow between the stakeholders thus assisting the design process to be standardised. To enable a reduction in variability during construction, buffers can be used to absorb variability through optimization. This system collaboratively aligns people, system and business processes so that Eskom can optimize value, reduce waste and maximize effectiveness through all phases of the project (Ballard, 2000). Eskom will harness the following benefits by implementing LPDS:

Benefits for the planning and design phases -

- Reduction in planning decisions at the last responsible moment
- The designers will have less reworks
- There will be a system for managing relationships and communication
- Designers will be able to create sustainable quality designs by minimising iteration
- An improved design documentation time

Benefits for the construction phase –

- The contractors have a lean design to execute a project
- The material element is deliberated at the outset and with the lean design; the construction variations will be reduced.

- The containment of construction overruns and over expenditure is managed
- The contractor is able to plan the project site and work towards the project management plan that was initiated at the onset of the project.

The recommendation to implement LPDS to manage projects will assist Eskom in shortening the project delivery times by delivering improved value with less hassle than the conventional approach.

5.4 Additional Recommendations to the Business

- Eskom should establish a project management office that will serve all operating units. This will be a centre of excellence where knowledge sharing is possible. This centre will need to accommodate training needs for project specific staff and be in a position to introduce new work methods or as the need defines it.
- Proper costing tools should be implemented throughout the business in order to improve the current costing challenges.
- Detailed project execution policies and procedures are to be visible and understood by all employees and contractors.
- A training centre should be established for training of contractors as this will assist with understanding design specifications and construction processes according to Eskom standards. This will assist in bridging the knowledge gap leading to extreme savings in time and costs.

5.5 Limitations of the Study

During the survey on the evaluation of lean principles to improve project performance, only four from the seven programme managers participated and only twenty-one of the technical project staff responded to the survey, therefore the researcher concludes that the results cannot be reasonably generalized to Eskom KZN Operating Unit.

5.6 Future Research

This study reviewed the applicability of lean principles in a project related environment taking into account the conventional project model. Further research is required to show the impact of using lean principles to improve the productivity of projects. A proposed framework can be suggested by using case studies as an appropriate way to investigate the

existing processes used in the delivery of projects. The proposed framework should be piloted at project level by carrying out action research.

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Appendix 1: Questionnaire

Questionnaire on Implementing Lean Techniques in a Project Environment

Please complete the questions below by checking (✓) the relevant box or providing the answer in the space provided.

SECTION A: BACKGROUND INFORMATION

Q1. **General Information**

Name of Participant _____

Company Name _____

Project Area _____

Q2. **Your experience in the project environment**

- ☐ 0 to 5 years
- ☐ 5 to 10 years
- ☐ 10 to 15 years
- ☐ 15 to 20 years
- ☐ Above 20 years

Q3. **Project Class**

Choose the project class that best describes your experience in projects

- ☐ Greenfield Project
- ☐ Brownfield Project
- ☐ Link Line
- ☐ Substation
- ☐ Lines

Q4. **Project Role**

Please select the role that best describes your function in the project

- ☐ Clerk of Work / Quality Control
- ☐ Project Coordinator
- ☐ Project Manager
- ☐ Programme Manager
- ☐ Portfolio Manager
- ☐ Assistant Finance Officer
- ☐ Project Scheduler
- ☐ Senior Manager
- ☐ Technical Manager
- ☐ Health and Safety

Q5. **Project Size**

Provide an indication of the size of the project you work on.

- ☐ 0 to 10 million
- ☐ 10 to 20 million
- ☐ 20 to 30 million
- ☐ Above 30 Million

Disclaimer: All information provided is strictly confidential and will not be disclosed. Information is being gathered for academic purposes only.

Questionnaire on Implementing Lean Techniques in a Project Environment

Please complete the questions below by checking (✓) the relevant box or providing the answer in the space provided.

SECTION B: BACKGROUND INFORMATION

General Project Deliverables - Time, Cost, Quality and Scope of Work

Q1. **Choose a value from the table below that bets describes the complexity of the project/s you work on**

Rating Scale	Very Low	Low	Average	High	Very High
	1	2	3	4	5

Complexity in terms of Design, Construction methods used, Technology, etc…

	Complexity
☐ Greenfield Project	☐
☐ Brownfield Project	☐
☐ Link Line	☐
☐ Substation	☐
☐ Lines	☐
☐ Other	☐

Please specify _____

Q2. **Provide an indication of the impact of the factors listed below on the overall performance of the project with regards to time, cost, quality and scope of work.**
Select the factor and then and then indicate the impact of the principles.

Rating Scale	Very Low	Low	Average	High	Very High
	1	2	3	4	5

More than one factor can be selected

	Time	Cost	Quality	Scope of Work
☐ Complex project design	☐	☐	☐	☐
☐ Inadequate details in the design	☐	☐	☐	☐
☐ Discrepancies/Mistakes in the design package	☐	☐	☐	☐
☐ Inadequate planning during initiation of the project	☐	☐	☐	☐
☐ Insufficient information compiled during survey and design	☐	☐	☐	☐
☐ Difficulties in financing the project/s	☐	☐	☐	☐
☐ Inadequate use of available technologies	☐	☐	☐	☐
☐ Poor / Ineffective project scheduling	☐	☐	☐	☐
☐ Variation orders during construction	☐	☐	☐	☐
☐ Improper construction methods	☐	☐	☐	☐
☐ Rework due to poor construction	☐	☐	☐	☐
☐ Poor site management	☐	☐	☐	☐
☐ Site uncertainties	☐	☐	☐	☐
☐ Poor qualification of project staff / Lack of skill	☐	☐	☐	☐
☐ Weak communication and coordination by project staff	☐	☐	☐	☐
☐ Delay in material requirements	☐	☐	☐	☐
☐ Change in material type during construction	☐	☐	☐	☐
☐ Material damages, whilst material is needed.	☐	☐	☐	☐
☐ Low productivity	☐	☐	☐	☐
☐ Unskilled workforce	☐	☐	☐	☐
☐ Other	☐	☐	☐	☐

Please specify _____

Disclaimer: All information provided is strictly confidential and will not be disclosed. Information is being gathered for academic purposes only.

Q3. **Please specify the main drivers for the project/s you oversee.**
Select the driver/s then rate according to their importance

Rating Scale	Very Low	Low	Average	High	Very High
	1	2	3	4	5

More than one principle can be selected

	Importance
☐ Time	☐
☐ Cost	☐
☐ Quality	☐
☐ Scope of Work	☐
☐ Other	☐

Please specify _____

Q4. **Do you take corrective action when the project/s is driven by any of the above principles?**

☐ Yes
☐ No

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Questionnaire on Implementing Lean Techniques in a Project Environment

Please complete the questions below by checking (✓) the relevant box or providing the answer in the space provided.

Q5. **If the response is Yes, then select the option/s that helps you to manage the project within the above mentioned principles**

Rating Scale	Very Low	Low	Average	High	Very High
	1	2	3	4	5

More than one option can be selected

		Impact
☐	Consider alternate designs	☐
☐	Consider different materials	☐
☐	Reduce the number of contract labour	☐
☐	Look into using multi skilled labour	☐
☐	Using forward looking schedules to reduce inventory (Pull Approach)	☐
☐	Reduce waste	☐
☐	Mitigate delays	☐
☐	Other	☐
	Please specify _____	

SECTION C: KNOWLEDGE OF LEAN PROJECT PRINCIPLES

Q1. **Is there a potential to introduce new approaches to improve project delivery?**

- ☐ Very low
- ☐ Low
- ☐ Average
- ☐ High
- ☐ Very high

Q2. **What is your understanding of lean principles?**

- ☐ Very low
- ☐ Low
- ☐ Average
- ☐ High
- ☐ Very high

Q3. **Do you use computer aided tools to manage your project/s?**

- ☐ Yes
- ☐ No

Q4. **If yes, please indicate what tools are used.**

- ☐ Microsoft project

Q5. **Please indicate the efficiency of using the above tools**

- ☐ Very low
- ☐ Low
- ☐ Average
- ☐ High
- ☐ Very high

Q6. **Please provide a reason for selecting the level of efficiency**

_____

_____

_____

Q7 **With regards to your experience, evaluate the importance of the following lean principles with the aim of improving project performance.**

Rating Scale	Very Low	Low	Average	High	Very High
	1	2	3	4	5

More than one principle can be selected

7.1 **Reduction in waste**	Level of Importance
Indicate your level of importance to reduce non-value adding activities in the project	☐
Provide an indication of the level of material waste at the project site	☐
Are project team members aware of waste elimination	☐
Do you consider unneeded movements of material to and within the project site	☐
Do you consider under utilised team members as wasteful	☐
Can you quantify material waste	☐
Can you quantify unproductive labour	☐

Disclaimer: All information provided is strictly confidential and will not be disclosed. Information is being gathered for academic purposes only.

Questionnaire on Implementing Lean Techniques in a Project Environment

Please complete the questions below by checking (✓) the relevant box or providing the answer in the space provided.

7.2 **Reduction in variability**	Level of Importance
Is the design process standardised in order to reduce variability during construction	☐
Is the construction process standardised to reduce change requests	☐
Is this process communicated to the project team	☐
Do you review the design before going into construction	☐

7.3 **Flow variability**	Level of Importance
Do you review the project schedule to improve work flow	☐
Do you use a communicating tool to ensure project related information flows to all project departments	☐
Do you use a just-in-time material system to manage the volume of materials at the project site	☐
Do you used multi skilled labour for different activities on site (flexibility of work)	☐
Do you consider an efficient flow of materials, communication and resources at the project site	☐

7.5 **Process variability**	Level of Importance
Is there a morning meeting of the project team before commencing with activities.	☐
Is there a morning safety meeting to identify risks and action plans	☐
Is quality assessment being done on activities	☐

7.6 **Increase transparency**	Level of Importance
Your concern level regarding house keeping at the project site	☐
Do you clarify construction methods to the project team	☐
Do you use a visual management system at the project site, example safety signs, status boards, etc.	☐
To what extent is the need to establish communication channels with stakeholders, engineers, contractors and customers	☐

7.7 **Continuous improvement**	Level of Importance
Do you have a measurement system that is used to quantify unused materials	☐
To what extent do you manage project performance (use of benchmarks to measure performance)	☐
Do to take any proactive measures to prevent defects at the source	☐
To what extent are the employees contributing to process improvement	☐
To what extent do you consider customer feedback for process improvement	☐
To what extent do you share project learnings to other teams	☐

7.8 **Customer focus**	Level of Importance
The level of flexibility to meet changes	☐
The extent of communication between contractor and customer	☐

Q8. **Please provide any additional comments below.**

Disclaimer: All information provided is strictly confidential and will not be disclosed. Information is being gathered for academic purposes only.

Appendix 2: Respondents Consent Form

Dear Respondent,

MBA Research Project
Researcher: Keshrie Padayachee (27 82 493 5213)
Email Address: padayak@eskom.co.za
Supervisor: Dr. Elias Munapo (0027 31 260 8943)
Email Address: munapoe@ukzn.ac.za
Research Office: Ms Mariette Snyman (0027 31 260 8350)
Email Address: Snymanm@ukzn.ac.za

I, Keshrie Padayachee, (Student Number: 213572000), an MBA student at the Graduate School of Business and Leadership, of the University of KwaZulu-Natal, and also working as Technical Sales Manager for SA Calcium Carbide (Pty) Ltd, kindly invite you to participate in a research project entitled:

"Evaluating the Application of Lean Principles to Improve Project Performance at Eskom KZNOU".

I, Keshrie Padayachee a MBA student, studying at the Graduate School of Business based at the University of KwaZulu Natal hereby request you to participate in this research project titled "A Critical Evaluation of Applying Lean Principles to Eskom's Electrification Project delivery Model in the KwaZulu Natal Operating Unit." The intention of this project is to establish the impact of lean principles as a business tool to eradicate non value adding activities in the existing project delivery model within Eskom in KwaZulu Natal.

Through your participation I hope to understand the value of Lean principles. The results of the survey are intended to successfully contribute to the execution of projects within the South African operations. Your participation in this study is voluntary. You may refuse to participate or withdraw from the survey at any time with no negative consequence. There will be no monetary gain from participating in this survey. Confidentiality and anonymity of records identifying you as a participant will be maintained by the Graduate School of Business, UKZN.

If you have any questions or concerns about completing the questionnaire or about participating in this study, you may contact me at the number listed above.

The survey should take you about 20 minutes to complete. I hope you will take the time to complete this survey.

.
Sincerely

Student/Researcher Signature: ..... Date: .....

This page is to be retained by the participant.

Dear Respondent,

MBA Research Project
Researcher: Keshrie Padayachee (27 82 493 5213)
Email Address: padayak@eskom.co.za
Supervisor: Dr. Elias Munapo (0027 31 260 8943)
Email Address: munapoe@ukzn.ac.za
Research Office: Ms Mariette Snyman (0027 31 260 8350)
Email Address: Snymanm@ukzn.ac.za

Research Project Title:

"Evaluating the Application of Lean Principles to Improve Project Delivery at Eskom KZNOU".

CONSENT

I…….. (Full names of participant)

Working for …… (Full company name)

Hereby confirm that I fully understand the contents of this document and the nature of the research project and I consent fully to participating in the research project.

I understand that I am at liberty to withdraw from the project at any time, should I so desire.

SIGNATURE: ---------- DATE: ----------

Appendix 3: Company Consent Form

Eskom
KZN Operating Unit

Electrification Portfolio Manager
Eskom
1 Langford Road, Westville
Kwa-Zulu Natal

05 August 2015

For Attention: Ms Khanyisa Sihlobo

I, Keshrie Padayachee, am currently studying towards my MBAD at the University of KwaZulu Natal, as a part time student.
The proposed topic selected for my dissertation is as follows:

"Evaluating the Application of Lean Principles to improve Project Delivery at Eskom KZNOU ."

This project will be conducted under the supervision of Dr Elias Munapo.
The overall goal of this study is to understand if/how lean principles are applicable in a project management environment, to identify areas of improvement and provide a proposal which Eskom can consider utilising to accelerate delivery of electrification projects.
This study will require me to circulate a questionnaire to role players in order to gain a better understanding of the electrification processes at Eskom. All information gathered from participants in the study will be treated with the highest level of confidentiality.
I hereby seek your consent to undertake this study on the proposed title within Eskom: KZN Electrification offices. This is a totally independent research that I am conducting for my MBAD, with no liability to Eskom in any way. This exercise is being undertaken for study purposes.

Thanking you kindly in advance.

Keshrie Padayachee

Eastern Region
Electrification Department
01 Langford Road, Westville, 3630 (Block C, Ground floor)
Tel +27 31 279 6424 Fax +27 31 279 6409 www.eskom.co.za

Name: **Khanyisa Sihlobo**

Designation: **Electrification Portfolio Manager**

Contact details (w): **031 2796425**

Cell: **+27 83 535 9952**

Email address: SihlobKP@eskom.co.za

Approval from Relevant Authority

1. Permission (Granted) / Not Granted

2. Permission Granted with Conditions / (No Conditions)

Signature: _____ Date: 05 August 2015

Eastern Region
Electrification Department
01 Langford Road, Westville, 3630 (Block C, Ground floor)
Tel +27 31 279 6424 Fax +27 31 279 6409 www.eskom.co.za

Appendix 4: Language Editor Confirmation Letter

Angela Bryan & Associates

6 La Vigna
Plantations
47 Shongweni Road
Hillcrest

Date: 12 February 2016

To whom it may concern

This is to certify that the MBA Dissertation: Evaluating the Application of Lean Principles to Improve project Performance at Eskom KZNOU written by Keshrie Padayachee has been edited by me for language.

Currently an English teacher at a private Secondary school, Angela has a Bachelor's degree specialising in English and Psychology. Her clients include academics from a number of universities, some of which are UKZN, Medical School, Rhodes and NWU. She has edited numerous articles for overseas publications including several translations from foreign languages.

Please contact me should you require any further information.

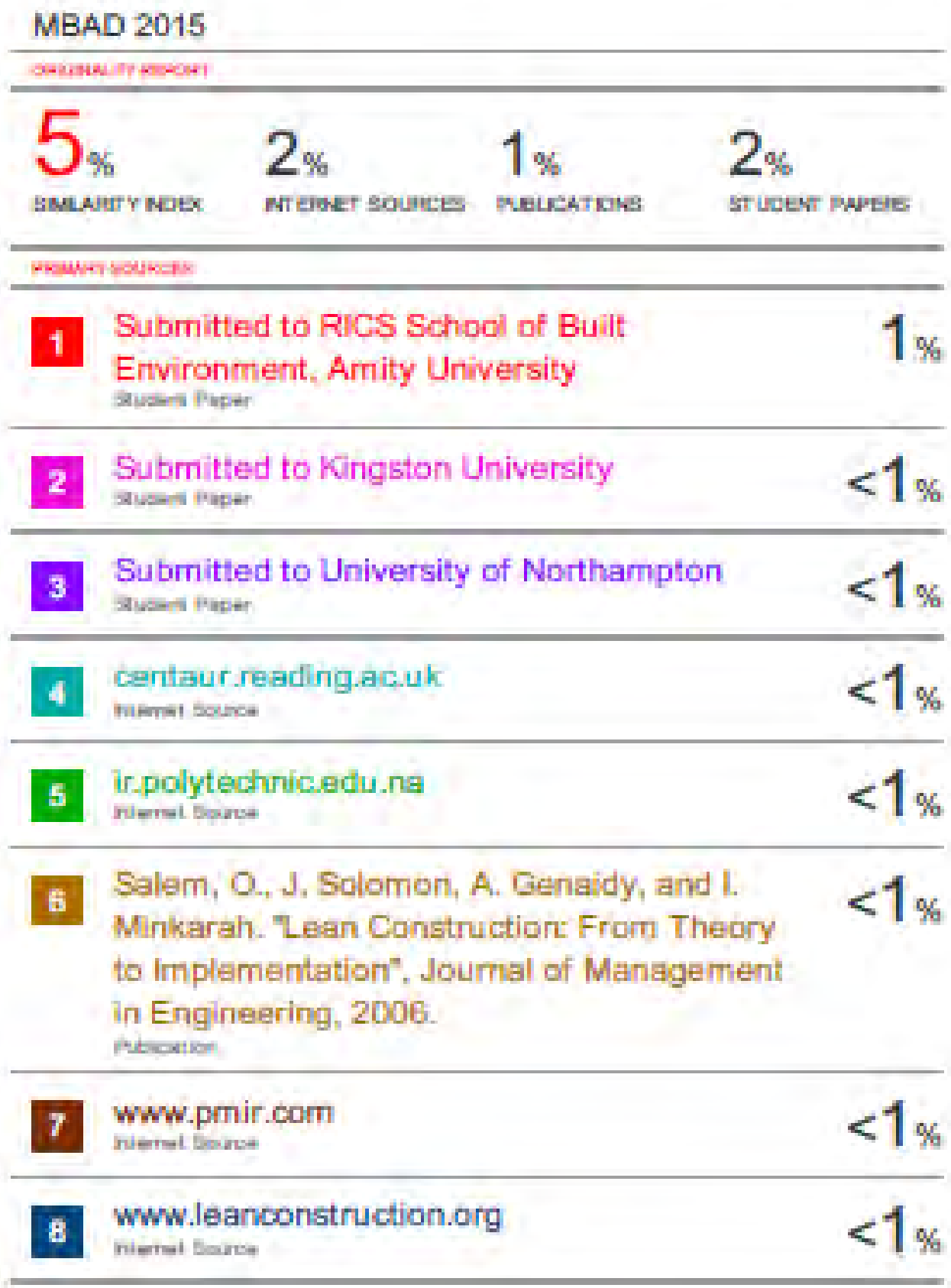
Kind Regards

Angela Bryan

angelakirbybryan@gmail.com

0832983312

Appendix 5: Turnitin Receipt



MBAD 2015

ORIGINALITY REPORT

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Appendix 6: Ethical Clearance Certificate

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

28 August 2015

Ms Keshrie Padayachee (213572000)
Graduate School of Business & Leadership
Westville Campus

Dear Ms Padayachee,

Protocol reference number: HSS/0775/015M
Project title: Evaluating the Application of Lean Principles to Improve Project Performance at Eskom KZNOU

Full Approval – Expedited Application

In response to your application received on 23 June 2015, the Humanities & Social Sciences Research Ethics Committee has considered the abovementioned application and the protocol have been granted **FULL APPROVAL.**

Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment/modification prior to its implementation. In case you have further queries, please quote the above reference number.

PLEASE NOTE: Research data should be securely stored in the discipline/department for a period of 5 years.

The ethical clearance certificate is only valid for a period of 3 years from the date of issue. Thereafter Recertification must be applied for on an annual basis.

I take this opportunity of wishing you everything of the best with your study.

Yours faithfully

.....
Dr Shenuka Singh (Chair)

/ms

Cc Supervisor: Dr Elias Munapo
Cc Academic Leader Research: Dr Muhammad Hoque
Cc School Administrator: Ms Zarina Bullyraj

Humanities & Social Sciences Research Ethics Committee
Dr Shenuka Singh (Chair)
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Website: www.ukzn.ac.za