The adoption of lean manufacturing principles in electronic manufacturing: a case of Altech UEC

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ABSTRACT

Electronic manufacturers are at increasing risk from offshore competition; often due to significantly lower labour costs abroad (Roberts, 2012). The implications are serious and, ignoring the threat, will, at best, lead to loss of market share and, at worst, the closure of many businesses with significant effect on the South African economy and society. This kind of competition has been seen in other industries. The clothing industry in South Africa, for example, has either failed or moved offshore. Traditional manufacturing production systems offer no solution to the problem, while a lean manufacturing has been associated with productivity increase, quality improvement, reduction of lead time and cost (Marudhamuthu & Krishnaswamy, 2011). According to Taj and Morosan (2011), waste is anything other than the minimum amount of equipment, materials, parts and working time which is absolutely vital to production.

The focus of this study is the adoption of lean manufacturing principles in the electronic manufacturing industry in South Africa: a case of Altech UEC. The aim of this research is to identify the possible or potential of adopting lean manufacturing principles in the electronic manufacturing industry and, in particular, Altech UEC. The study identified the tools, techniques and drivers for implementation. In order to achieve the aim of the study, the following objectives were developed:

- To capture employees' perception of lean manufacturing and the principles that they believe have been implemented within Altech UEC;
- To establish the impact being made or lack thereof of implementing lean manufacturing at Altech UEC;
- To ascertain the challenges being faced by the implementation of lean manufacturing at Altech UEC; and
- To explore the ways in which the implementation of lean manufacturing can be improved within Altech UEC.

For the purpose of obtaining necessary information, the researcher employed a descriptive research design. With this research design, the primary data needed in this research are derived from the answers of the respondents of the survey through a previously used questionnaire.

This study sought to explore the use and implementation of lean manufacturing principles at Altech UEC as the basis for understanding how lean manufacturing can benefit an organisation within a South African context. There were four research questions asked under the broader topic of lean manufacturing and through extensive research of previous literature and logical inferences made from the analysis of the data it was found that while some aspects of lean manufacturing principles were being used to improve upon the lean manufacturing process, there was still a great deal of improvement for Altech UEC to be a lean manufacturing organisation.

The study was able to effectively conclude that lean manufacturing impacts positively on the manufacturing process and, if implemented correctly, the manufacturing process will run smoothly and efficiently. The more lean manufacturing aspects applied to the manufacturing process, the more likely it was to run smoothly and efficiently at an increased rate of production.

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The lesson we are taught from early childhood in our mother tongue: **MATHA, PITHA, GURU, DEIVAM**, which, when translated, means: **Mother, Father, Teacher and God**. With this teaching philosophy, I would like to express my sincere gratitude to the following people for their support and contribution throughout this journey:

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Declaration by Candidate

I hereby declare that this dissertation submitted is my original work unless specifically acknowledged as being sourced from other persons. This dissertation has not been submitted to any other institutions for any other degree.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

INTRODUCTION TO THE RESEARCH

1.1 Introduction

Lean manufacturing minimizes waste within the manufacturing process to optimise the rate at which manufacturing takes place and the process of manufacturing improves in quality which, in turn, improves the quality of the product (Karlsson and Ahlstrom, 1996). The research undertaken is at an organisation, namely, Altech UEC, as a case study and gathers data from employees with regards to their perspective and the different lean manufacturing principles that have been implemented within Altech UEC. This introductory chapter presents the research context which provides the background to the research and the research problem. It also details the aim, objectives and the research question and outlines the research methodology for the study. This chapter also highlights the significance of the study, delimitation of the study, conceptual framework and definition of key terms. The chapter concludes with an outline of the chapters comprising this dissertation.

1.2 Background

Altech UEC is an electronic organisation manufacturing set top box (satellite and terrestrial receivers) for the pay television and free-to-air market. The organisation is based in Mount Edgecombe, Kwa-Zulu-Natal, South Africa. The organisation is known for high quality, reliable design and efficient manufacturing capability. Altech UEC has won a number of awards for technology top 100 over the years for Research and Development, and Export awards for manufacturing (Altron, 2015) Technology top 100 awards shows that companies have embraced the management of technology, innovation and people in a systemic and sustainable manner (Kramer, 2014).

Globalisation has led to many companies relocating their manufacturing plants to China. A combination of low wages, specialised regional networks and product exporters has enabled China to become the global economy low-cost supplier (Naidoo, 2007). Taj and Morosan (2011) state that China has become the manufacturing hub of the world, and many global companies have established manufacturing plants in China, mainly due to lower wage rates and lower costs of manufacturing and raw materials.

The demise of the South African clothing and textile industry is the classic example of an industry that yielded to lower offshore production costs. China's share of South Africa's total imports of clothing and textiles grew from 16.1 percent in 1996 to 60.7 percent in 2008 (Biacauna, 2009). Biacauna (2009) also estimated that in the last 6 years 69 000 jobs have been lost in the clothing and textiles sector, a drop of 39 percent; therefore, labour unions have strongly lobbied for protection to limit further job losses. Ramdass (2007) states that Chinese imports are impacting on global clothing and textile manufacturing because of their low production costs. China is raising the benchmark of competition in the value for the manufacturing sector in South Africa

The South African Automotive industry, on the other hand, has been more resilient where lean manufacturing is the mainstay. Bhamu and Sangwan (2014) state that the goal of lean manufacturing is to be highly responsive to customer demand by reducing waste. Lean manufacturing aims at producing products and services at the lowest cost and as fast as required by the customer with the aim to eliminate unnecessary processes, increase productivity, enhance quality and shorten lead times, thereby reducing the overall cost (Karlsson and Ahlstrom, 1996).

Marudhamuthu and Krishnaswamy (2011) also state that lean manufacturing implementation is associated with productivity increase, quality improvement, reduction of lead time and cost.

The success of lean manufacturing in the automotive industry is no panacea for cost saving in other industry sectors and the history of implementation in other sectors is paved with cases of failure and limited success. The implementation of lean manufacturing principles in the sugar industry in Kenya was not very successful due to there not being a systematic approach to implementation, resulting in lean practices being implemented in isolation and, therefore, not reaping the full benefit (Ondiek and Kisombe, 2013).

1.3 Problem Statement

During 2013, in anticipation of orders Altech invested R60 million to expand and upgrade the factory infrastructure to meet the demand for terrestrial set top box (STB) where Altech UEC's biggest market was the rest of Africa where digital terrestrial television (DTT) is being rolled (Tirvengadum, 2014). However, many of the orders have not materialised.

According to a report in the financial mail by Mungadze and Mochiko (2015), the main reason cited by the customer was cost.

As a reactionary measure, Altech UEC had to retrench 100 full-time employees and 325 temporary employees during the 2015 financial year (Altron, 2015). Such drastic action may provide only short-term relief and, in the long-term, the organisation will gravitate to a negative state of affairs, if it does not find ways to remain competitive. As the organisation struggles to remain profitable, the organisation must look at ways to reduce costs and there have been murmurings in the 'grapevine' of the possible implementation of lean manufacturing principles.

In the electronic industry in Malaysia, companies that have implemented lean manufacturing have gained benefits, such as reduced costs and improved productivity, due to the companies adopting lean tools in a very integrated manner (Wong, Wong and Ali, 2009). The manufacturing processes at Altech UEC follow an assembly line, very much like that in automotive manufacturing. So, the potential for successful implementation of lean manufacturing principles could be much higher than that for industries where the manufacturing processes are much different (Ganguly, Dash and Bandyopadhyay, 2013). The aim of this research is to identify the possible or potential of adopting lean manufacturing principles in the electronic manufacturing industry and in particular, at Altech UEC. The study uses a quantitative approach for the exploration of the perspectives of employees with regards to lean manufacturing and the methods of lean manufacturing that have been used within the organisation, and the impact this has on the manufacturing process, as well as the challenges faced by the implementation of lean manufacturing and the ways in which this can be improved.

1.4 Objectives

The objectives of this study are as follows:

- To capture employees' perception of lean manufacturing and the principles that they believe have been implemented within Altech UEC;
- To establish the impact being made or lack thereof of implementing lean manufacturing at Altech UEC;
- To ascertain the challenges being faced by the implementation of lean manufacturing at Altech UEC; and

- To explore the ways in which the implementation of lean manufacturing can be improved within Altech UEC.

1.5 Research Questions

This research has four research questions that are going to be examined:

- What are the perceptions of employees of lean manufacturing and the principles that they believe have been implemented within Altech UEC?
- What is the impact (or lack thereof) of implementing lean manufacturing at Altech UEC?
- What are the challenges being faced by the implementation of lean manufacturing at Altech UEC?
- What are the ways in which the implementation of lean manufacturing can be improved within Altech UEC?

1.6 Aim of the Research

The aim of this research is to identify the possible or potential of adopting lean manufacturing principles in the electronic manufacturing industry and in particular, at Altech UEC.

This research will provide an in-depth analysis of the implementation of lean manufacturing within the manufacturing organisation, Altech UEC. The questions compiled in the questionnaire that was distributed to participants covers a number of issues of interest under the various lean manufacturing principles that were listed as vital by Karlsson and Ahlstrom (1996). These lean manufacturing principles include elimination of waste, continuous improvement, zero defects, just-in-time, decentralised responsibilities, integrated functions, pull instead of push, visual management and single minute exchange of dies (SMED). This study seeks to identify the principles and aspects of lean manufacturing currently in use and how they impact on the manufacturing process within the organisation, as well as the contextual specific challenges that faced the implementation of lean manufacturing principles within the manufacturing process.

This research will be different from other studies conducted into the analysis of lean manufacturing as it looks at the technological industry specifically. While most studies survey employees on the more technical aspects of lean manufacturing, this study looks at the perspectives of the employees who were interviewed and what they feel should be a part of the manufacturing process, as well as how they feel the manufacturing process is affected by lean manufacturing.

1.7 Conceptual Framework

According to Popper (1994), a framework is a set of basic assumptions and fundamental principles in which discussion and actions can proceed. Aalbregtse, Hejka and Mcneley (1991) define a framework as being one which provides a clear picture of the leadership goal for the organisation and should present key characteristics of the to-be style of business operations. A sound implementation plan should define what the organisation does, what it is trying to do and how it is going to do it, ensuring that each step builds on the previous one, according to Struebing and Klaus (1997, cited in Yusof and Aspinwall, 2000). According to Hakes (1991), a sound framework secures links between concepts and practical application.

Below is a conceptual framework of this study:

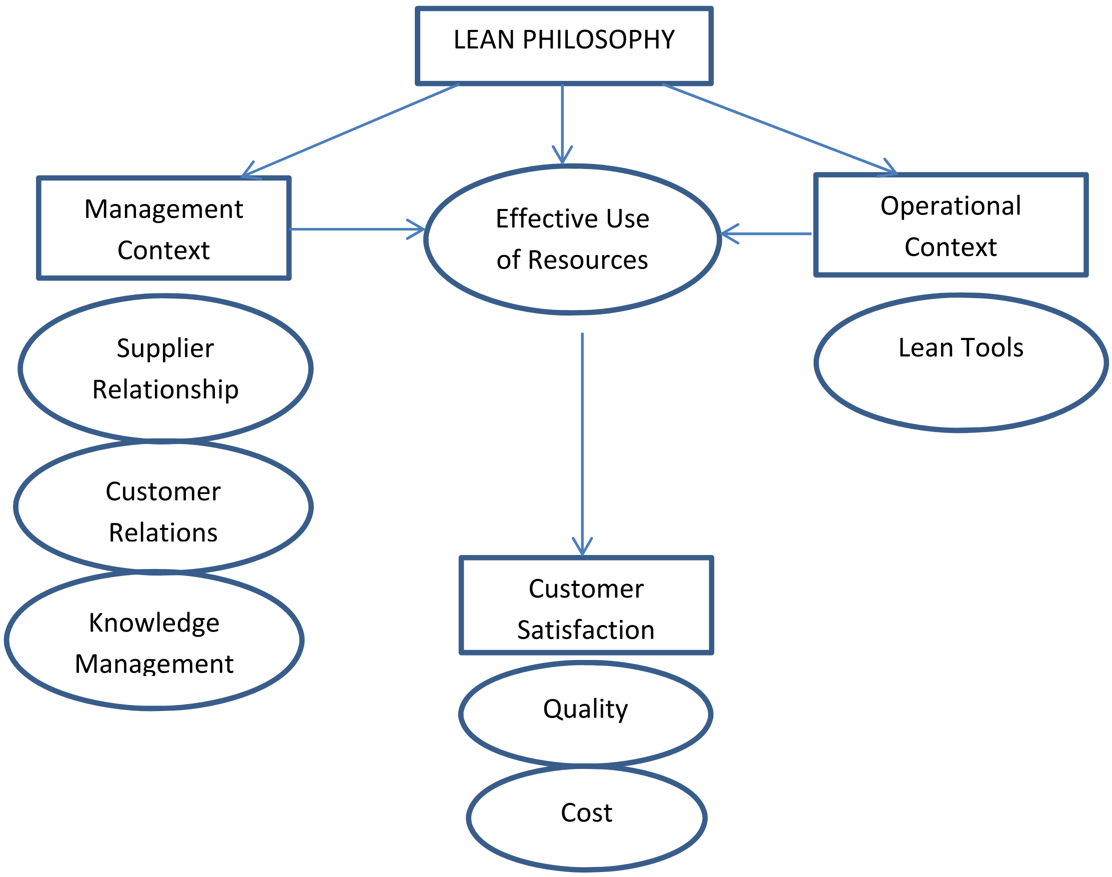

Figure 1.1: Conceptual Framework

Lean, as a philosophy, embraces the managerial context (supplier relationship management, customer relationship and knowledge management) and operations context (deployment of lean tools), which, together, lead to the effective use of resources resulting in customer satisfaction. These concepts are dealt with further in the literature review (chapter 2).

1.8 Research Methodology

According to Sekaran and Bougie (2010), studies may be either exploratory in nature or descriptive. Sekaran and Bougie (2010) state that an exploratory study is undertaken when not much is known about the situation at hand or no information is available on how similar problems or research issues have been solved in the past. Sekaran and Bougie (2010) explain that exploratory studies are undertaken to better comprehend the nature of the problem since very few studies might have been conducted in that area. Babbie and Mouton (2001) state that the key differences are that exploratory research entails investigating unknown areas of research, while descriptive is focussed on describing phenomena without providing causal explanations, and explanatory research provides causal explanations of phenomena.

A descriptive research is undertaken in order to ascertain and to be able to describe the characteristics of the variables of interest in a situation (Sekaran & Bougie, 2010). Sekaran and Bougie (2010) further state that descriptive studies are also undertaken to understand the characteristics of organizations that follow certain common practices. Descriptive studies, thus, become essential in many situations. Whereas qualitative data obtained by interviewing individuals may help the understanding of phenomena at the exploratory stages of a study, quantitative data, in terms of frequencies, or mean and standard deviations, become necessary for descriptive studies (Sekaran & Bougie, 2010).

For the purpose of obtaining necessary information, the researcher will employ the descriptive research design. According to Creswell (2005), to be able to gather information about the present existing condition, the descriptive method of research must be utilized. Leedy and Ormrod (2005) further state that descriptive research, which includes observation studies, correlation studies, developmental design and survey research, yields quantitative data that can be summarised through statistical analysis. With this research design, the primary data needed in this research will be derived from the answers of the respondents of the survey through a questionnaire adapted from previous studies.

1.9 Population and Sampling:

The number of employees on site was obtained from the human resources database. The current population size, including operators and junior to middle management, is approximately 250 employees. According to Sekaran and Bougie (2010), for a population of 250, a sample size of 152 is considered to be satisfactory. Sekaran and Bougie (2010) also state that there are two major types of sampling design: probability and non-probability sampling. According to Welman, Kruger and Mitchell (2005), probability sampling is where the probability of any element or member of the population that will be included in the sample can be determined, whereas, in non-probability sampling, the probability of elements being included in the sample cannot be specified. For this study, the researcher will use stratified random sampling. Kothari (2010) states that, if the population from which a sample is to be drawn does not constitute a homogeneous group, then stratified sampling technique is to be applied to obtain a representative sample. Sekaran and Bougie (2010) also state that, for stratified random sampling, the population is first divided into mutually exclusive groups that are relevant, appropriate and meaningful in the context of the study. For this study, the groups will be middle managers, line managers and employees.

1.10 Significance of study

This study is important for a number of reasons. Firstly, the organisation being researched will be able to evaluate their readiness for the adoption of lean manufacturing. Secondly, the organisation will be able to ascertain areas that need to improve so that the organisation can reduce costs through lean manufacturing and become more efficiient. This improvement will be useful for similar organisations in the same industry to grow and become more competetive in the market.

1.11 Delimitation

This study will be conducted at Altech UEC in Mount Edgecombe, Kwa-Zulu-Natal. The participants for this study will be the employees of Altech UEC comprising of shop floor employees, and junior to middle management. Altech UEC was chosen as the organisation as the problem statement relates directly to Altech UEC. While the organisation may not be representative of all organisations, the recommendations could be applicable to other organisations in the same industry, specifically those that can run product lines relating to electronics.

1.12 Key Definitions

Decentralized Responsibilities	The process of transferring and assigning decision-making authority to lower level employees in an organisation hierarchy (Forza, 1996).
Elimination of waste	is any activity in production that does not add value to the finished product, such as excess inventory, unnecessary movements of employees, scrap, rework or transportation (Shah and Ward, 2007).
Inventory	is the raw materials, work-in-process products and finished goods that are considered to be the portion of a business's assets that are ready or will be ready for sale (Womack and Jones, 1996).
Integrated Functions	A philosophy that enables employees to perform many different tasks in production (Karlsson and Ahlstrom, 1996).
Just in Time	is an inventory strategy companies employ to increase efficiency and decrease waste by receiving goods only as they are needed in the production process, thereby reducing inventory costs (Womack and Jones, 1996).
Kaizen	Kaizen is the Japanese word for "continuous improvement ". In business, kaizen refers to activities that continuously improve all functions and involve all employees from the CEO to the assembly line workers (Womack and Jones, 1996).
Multifunctional Teams	A group of employees that are organised in a particular work area and are able to perform many different tasks. These teams are often organised along a cell based part of the product flow (Karlsson and Ahlstrom, 1996).
SMED	Single-Minute Exchange of Die (SMED) is one of the many lean production methods for reducing waste in a manufacturing process. It provides a rapid and efficient way of converting a manufacturing process from running the current product to running the next product. Quick change overs, minimum downtime (Womack and Jones, 1996).
Toyota Production System	The Toyota Production System (TPS) is an integrated socio-technical system, developed by Toyota that

	comprises its management philosophy and practices (Womack and Jones, 1996).
Value Stream Analysis	Value stream mapping is a lean-management method for analysing the current state and designing a future state for the series of events that take a product or service from its beginning through to the customer (Womack and Jones, 1996).
Vertical Information Systems	The transfer of information to all employees within the organisation (Soriana-Meier & Forrester, 2002).
Zero Defects	is a management tool aimed at the reduction of defects through prevention. It is directed at motivating people to prevent mistakes by developing a constant, conscious desire to do their job right the first time (Womack and Jones, 1996).

1.13 Chapter Outline

This study comprises of five chapters that all work in conjunction with one another to support the research at hand. The first chapter provides an overview into the study as a whole and briefly looks at the research topic and the research questions and aims that supported the research conducted. The second chapter is a discussion of the literature that relates to the study and links it to the study as support for the topic of research. The third chapter provides an explanation of the methods that were used to conduct the study and provides a breakdown of the research design that was used. The next chapter is the results of the data analysis that was conducted on the data that was collected and provides all relevant graphs and tables that are linked to the study. The final chapter provides a discussion of the results that were achieved with the use of literature to support the results achieved and conclusions are drawn and recommendations are made.

1.14 Conclusion

This introductory chapter provided the research context to the background of the research and the research problem. It also detailed the aim, objectives, research questions and outlined the research methodology for the study. This chapter also highlighted the significance of the study, delimitation of the study, conceptual framework and definition of key terms. The next chapter comprises the literature review undertaken for this study.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The manufacturing industry in South Africa is constantly evolving and growing. Without the adoption of a manufacturing process that optimises efficiency, South African manufacturers are at risk of falling behind as they would struggle to compete with the rate of productivity abroad (Fricke, 2010). A manufacturing philosophy that is gaining attention is lean manufacturing, which focuses on the elimination of non-essential and non-value adding processes as a means of increasing efficiency and productivity in all areas of an operations system (Pepper and Spedding, 2009). While lean manufacturing has gained recognition at a relatively slow pace in South Africa, internationally, lean manufacturing has become the preferred method of production (Dominingo, 2013).

This literature review will first attempt to define lean manufacturing as a business philosophy and an operations system; thereafter, it will examine the history of lean manufacturing and compare lean manufacturing to the traditional mass production model. It will then analyse and discuss the principles of lean manufacturing and the challenges faced by lean manufacturing and conclude with the examination of the aspects that are required for a lean manufacturing model to run efficiently. This chapter will also examine previous studies into the impact lean manufacturing has made on the companies that implemented it.

2.2 Defining Lean Manufacturing

Lean manufacturing can be thought of as a business template that is focused on the creation of a flexible and efficient production process that minimises waste and maximises customer satisfaction (Lila, 2012). The phrase “manufacturing process” refers to all activities and resources that contribute to the manufacturing of a product, including the packaging and distribution or creation of an item required for the completion of the final product. Lean manufacturing, as the philosophy, when applied to manufacturing processes, results in the reduction of waste, human input and effort and time taken to complete a manufacturing process. Thus, “lean manufacturing is doing more with less” (Fricke, 2010). Lila (2012) believes that lean manufacturing transforms the entire organisation, affecting every department, and the manner in which choices are made to remove non-value processes while maintaining the fundamental principles of lean manufacturing. For this to happen, lean manufacturing must be understood as both an operations system, which refers to all technical processes required for the completion of a product, and as a business philosophy, which is a term used to describe how an organisation chooses to conduct business (Lila, 2012).

Bhasin and Burcher (2006) believe that, because lean manufacturing has not been properly understood as a model or philosophy by which a business should implement all processes at all operational levels, lean manufacturing has had a low success rate with some companies abroad. The reason for this low rate is that lean manufacturing is only used as a means of manufacturing a product, and the aspect of lean manufacturing, as part of a business model and philosophy of doing business, is ignored (Shah and Ward, 2007). “When seen as a philosophy it becomes a way of thinking whereas tactics of processes are mechanisms to action these thoughts” (Bhasin and Burcher, 2006:56). This means lean manufacturing must be fully incorporated into how, a business is carried out within an organisation and it must be integrated into the model, which is the strategy used to conduct business. It should not only be seen as a systemic approach to the organisation but should also be seen as a guideline on how a business should be managed and how it should manage its resources (Bhasin and Burcher, 2006). Shah and Ward (2007) argue that, by limiting lean manufacturing to an operations system, it reduces the level of efficiency that lean manufacturing is capable of providing to an organisation and the effect lean manufacturing has on how a business is run and its organisational culture. The implementation of lean manufacturing processes has a direct influence on performance within an organisation on all the processes involved in the successful functioning of an organisation, which essentially means the product being produced is done so at an increased rate and done so more efficiently than previous methods used (Oon, 2013).

According to Vienazindiene and Ciarniene (2013), lean manufacturing within a manufacturing environment can be thought of as an evolution to the mass production industry as it introduces new concepts of an accelerated line of operation and efficiency in the management of tenuous processes, such as the transport of materials as well as all the processes required for the product to reach the consumer. The implementation of lean manufacturing is a gradual process and is argued by Soriano-Meier and Forrester (2002) to represent a new era of manufacturing. The outcomes achieved by lean manufacturing vary from organisation to organisation, and there has been little done to provide a clear and comprehensive definition to the concept of lean manufacturing within the operational context (Mund, 2011). Soriano-Meier and Forrester (2002) sought to prove that, by applying lean manufacturing to all manufacturing industries, one could provide a clear definition to lean manufacturing. The study conducted by Soriano-Meier and Forrester (2002) concluded that lean manufacturing has a degree of applicability across all forms and industries in manufacturing. The study also found that the degree of implementation of lean manufacturing was also dependent on the view the management of an organisation chose to adopt lean manufacturing as a manufacturing process (Soriano-Meier and Forrester, 2002).

Lean manufacturing is a philosophy that can be applied to all aspects of an organisation, from the actual processes involved in creating a product to the administrative processes carried out by an organisation (Naidoo, 2012). Apart from being applied to an operational context, lean manufacturing can also be applied to a managerial context (Radnor, Walley, Stephens, and Bucci, 2006). Naidoo (2012) states that companies should see lean manufacturing as a management philosophy as it targets the efficient use of resources used in all aspects of business. Lean management, as a managerial concept, organizes the workplace and workflow to create a more efficient work environment, thereby boosting product quality, as it removes unnecessary processes and resources that may compromise the quality of a product (Naidoo, 2012). According to Garvin (1984), there are eight dimensions of quality, i.e., performance, features, reliability, conformance, durability, serviceability, aesthetics and perceived quality. Lean manufacturing also promotes the ability of an organisation to maintain its level of manufacturing and the reduction of resource wastage (Radnor et al., 2006). Arnheiter and Maleyeff (2005) believe that, by incorporating lean management into a business strategy, it effectively, in turn, changes the culture of a business. Arnheiter and Maleyeff (2005) goes on further to state that the emphasis lean management places on the quality of production ensures the comprehensive education of employees and the total fulfilment of a customer's needs. Lean management effectively removes wasteful processes and reduces unnecessary costs. Understanding the concept of lean management is the duty of every employee, from management level down to the shop floor level employees to ensure that lean management is used as an effective enabler of business efficiency and maximises profitability (Arnheiter and Maleyeff, 2012).

2.3 History of Lean Manufacturing

The philosophy and conception of lean manufacturing was first crafted by a Japanese industrial engineer, Taiichi Ohno (Black and Hunter, 2003). It was conceptualized by Ohno as a solution to the challenges the Japanese automotive organisation, Toyota, faced, after the

Second World War (Black and Hunter, 2003). It was created as a means of competing with the American automotive industry (Papadopoulou and Ozbayrak, 2005). After extensive investigation and research into the American automotive production line, particularly that of American automotive organisation Ford, Toyota then created and developed their own method of mass production (Nhlabathi, 2012). The development of a new production system led to the total reconstruction of Toyota as an organisation (Papadopoulou and Ozbayrak, 2005). This was largely due to the requirements the system would need to be functional and run at maximum efficiency (Arif-Uz-Zaman, 2013). As a result of this reconstruction, the alternative system of mass production was named the Toyota Production System and became renowned for the efficiency it made possible by reducing any form of waste from the mass production process (Papadopoulou and Ozbayrak, 2005).

As the system gained recognition and implementation, this system increased and research began to centre on perfecting and examining the Toyota Production System (Vermaak, 2008). One aspect that all researchers agreed upon was the evolution that lean manufacturing could bring to the process of mass production and the manufacturing industry as a whole (Papadopoulou and Ozbayrak, 2005). As the system slowly evolved from its original paradigm, the term lean manufacturing was coined by researcher Krafcik, which he used to refer as any mass production system that requires “less resources of everything” (Papadopoulou and Ozbayrak, 2005). The term lean manufacturing, however, was popularised by Womack et al. (1990, cited in Papadopoulou and Ozbayrak, 2005) in their book *The Machine that Changed the World* in which they described the lean manufacturing system to be a refined adaptation of the Toyota Production System. All components that encompass the lean manufacturing system today have been adapted and conceptualized by a number of sources since the inception of lean manufacturing to ensure the total efficiency and viability of lean manufacturing (Nhlabathi, 2013).

2.4 Traditional Mass production systems versus Lean Mass Production Systems

There has been resistance to the idea of lean manufacturing from companies who still make use of traditional mass production techniques (Ansari, n. d.). The significant difference between traditional mass production and lean mass production is that traditional mass production systems work according to projected sales expectations and excess stock is produced to be kept in inventory (Forza, 1996). Lean manufacturing works on the belief that production of goods should be dependent on realistic customer demand, that is, it produces the exact amount required by customers and no excess stock is created as it does not produce stock based on a projected sales target (Palm, 2006). A lean manufacturing system is capable of producing products of high quality at a cost efficient rate in lower numbers, thereby bringing them to sale at a faster rate than traditional mass production systems (Ansari, n. d.). There are key areas in which traditional mass production systems differ from lean manufacturing, and these areas, in turn, affect the way in which an organisation runs and how productive a business is (Ansari, n. d).

The business strategy of a traditional mass production system is focused on getting as much of a product produced based on the projected sales, and makes use of consistent product concepts and generic technological tools that produce a product of sub-optimal quality as a result of the lack of insight into what is required by the customer and a reliance on the projections made into the level of products that need to be manufactured (Forza, 1996). Lean manufacturing adopts a strategy focused on the needs of the customer and emphasizes the identification and exploitation of shifting trends that provide a competitive advantage as it focuses on the needs of the customer (Van Der Walt, 2012). Lean manufacturing focuses on the demands of the customer with zero defects according to when it is required and is made in accordance with the amount required by a customer (Mtshali, 2011). The production process, in traditional mass production companies, makes use of machines that work on a larger scale of product output. The workplace design is a functional layout, a singular or minimum level of skill is required by employees and there are long runs of production for the creation of large inventories of stock (Ansari, n. d.). Lean manufacturing makes use of machinery that requires human input for use, a structured work environment for employees; it makes use of employees who are capable of performing more than one activity in the manufacturing process and uses a continuous, one-piece flow of production with no inventory for excess stock (Hefer, 2009). These differences are the reason why lean manufacturing has been proven to be more successful. Without an inventory, it reduces the wastage of resources that go into the creation of excess stock and the use of multi-skilled level employees ensures that a number of processes can occur simultaneously (Ansari, n. d.). Production time is managed efficiently and the line of production ensures zero defects and high quality products (Palm, 2006).

2.5 Critical Success Factors of Lean Manufacturing

According to David (2008), the term "success factors" can be defined as the components that are necessary for the successful integration and implementation of lean manufacturing as a perpetual quality improvement system. The foundation of lean manufacturing has been thoroughly researched and validated within manufacturing researching to ensure its effectiveness as both an operations system and a way of running an organisation (David, 2008). Upon review of previous research into the success factors of lean manufacturing, several other factors, such as employment management and input management, were found to contribute to the effectiveness of lean manufacturing within a corporation, all of which Vermaak (2008) found to assist with the reduction of cost in processes and business operations and played a role in increasing the quality of production.

Manville, Greatbanks, Krishnasa and Parker (2012) found that one of the factors that played an integral role to the success of lean manufacturing is employee management and multifunctional team work on the part of employees. Vermaak (2008) defines multifunctional teamwork as an open line of communication between employees working in the manufacturing process and adjusting how they work to achieve a gradual outcome to working efficiently to achieve an outcome within a given space of time. It is the ability of a team working on the same process to effectively resolve problems together and work together as a single unit attempting to achieve a collective instead of as individuals working separately to achieve individual goals (Taggart, 2009). Multifunctional teamwork ensures that lean manufacturing is implemented correctly through the education of employees on the total reduction of waste (Manville et al., 2012). Furthermore, Moore (2006) states that, by ensuring that employees are sufficiently educated on the implementation and use of lean manufacturing within all operation systems, it ensures total efficiency in the workforce and that the optimum level of a product is being manufactured as a result of maximum utilisation of the workforce.

Rose, Deros and Rahman (2014) found that the input management has on the concept of lean manufacturing also played a role in the level of effectiveness lean manufacturing had within an organisation. David (2008) concurs, and believes that as the more orientated an organisation is towards the practice of lean manufacturing, the more successful lean manufacturing proves to be within the operations and practices of an organisation. The total amount of unnecessary activities and resources eliminated from a manufacturing process is dependent on the decisions made by management on the degree of impact that lean manufacturing is allowed to have on the technical and operational processes of an organisation (Rose et al., 2014). It is a broad-minded approach to what is required for the organisation to function and it is the responsibility of management to correctly identify the processes and resources that can be seen as a waste of time and have them removed from the manufacturing process (Neethling, 2009).

The manner in which an organisation interacts with its customers was also identified as a critical factor of success by Achanga, Shehaab, Roy and Nelder (2006). Customer management refers to the efficient and the "on-time" delivery of services and goods to a customer (Manville et al., 2008). According to David (2008), everything done within the process of lean manufacturing should be done with the needs of the customer being used as motivation. Achanga et al. (2006) echo this sentiment as lean manufacturing should not just be seen as an efficient operations system used to create a product but also the means used to meet the needs of the customer at a quicker, efficient and cost-effective manner. It also ensures that the quality of the product received by a customer is of the highest quality and done in the most efficient manner possible (Vermaak, 2008). Thus, the greater purpose of lean manufacturing can be thought of as a more efficient way to meet the needs of the customer (Manville et al., 2008).

Process management can be defined as a series of operations linked together to provide a result that has an increased level of quality and an increased monetary value (Jablonski, 1992). Successful lean manufacturing relies on higher priority processes, such as the design and production of a product working in conjunction with lower priority processes, such as administrative processes, like the typing of memos, to ensure the efficient function of lean manufacturing as a chain of operation (Vermaak, 2008). Lean manufacturing must be applied to every process that is required by an organisation to function effectively (Achanga et al., 2006). The process of lean manufacturing, as a process of management, involves reorganizing and re-evaluating the value that is added by the processes that are carried out within an organisation (Vermaak, 2008). Jablonski (1992) believes that the processes within lean manufacturing should be efficient and easily understood by employees so that they require minimal additional training to understand performing the process at hand. Thus, processes should be efficient and well organized and work as a chain in conjunction with one another (Vermaak, 2008).

2.6 Challenges to Lean Manufacturing

Lean manufacturing proves to have many benefits when implemented correctly and can effectively increase the production process of a manufacturing firm (Pingyu and Yu, 2010). The challenge lies in ensuring that it is correctly implemented to benefit a production line and ensure that it is functioning at optimum efficiency (Bhamu and Sangwan, 2014). Philip (2012) found that, if lean manufacturing was only introduced into the manufacturing sector of an organisation, it had a lower rate of success, as it was only being implemented as a tool of production and not as a means of running a business. Mwacharo (2013), who echoes the same sentiment concludes that lean manufacturing needed to be implemented as a strategy to all aspects of business operations, including the implementation of the concept of lean manufacturing to every sector within a business, which is inclusive of administrative departments, such as marketing or accounting. As a result, Pingyu and Yu (2010) found that the majority of companies that chose to implement lean manufacturing were larger manufacturing companies, as smaller to medium enterprises believed that the amount of reconstruction involved in implementing lean manufacturing was not feasible from a financial standpoint.

After lean manufacturing was implemented within an organisation, it was found that it was a challenge to maintain it as a legible process of production and as a systemic operation to conducting business (Mwacharo, 2013). Without the proper protocols and policies being put into place by an organisation, the use of lean manufacturing, as a continuous system of conducting business, proved to be untenable as there was no framework to support lean manufacturing as a permanent model of production and business management. Thus, companies gradually revert to former business strategies and manufacturing processes due to the lack of support structure for lean manufacturing implementation (Radnor, Walley, Stephens, and Bucci, 2006). The employees of an organisation can also show hesitance or resistance to the implementation of lean manufacturing due to the level of training and education that is required for the proper and correct implementation of lean manufacturing. Thus, the lack of thorough training in implementing lean manufacturing is also a factor to the reversion of business to traditional methods of manufacturing and operating a business as employees lack the training and skills to ensure that lean manufacturing is a continually used process (Pingyu and Yu, 2010).

The resistance of staff to the implementation of lean manufacturing has proven to be one of the larger challenges that is faced by an organisation when implementing lean manufacturing

(Radnor et al., 2006). A poor decision-making environment, in which leadership also lacks the required knowledge to properly implement lean manufacturing, contributes to the lack of interest and discontent experienced by employees and a lack of understanding for how lean manufacturing functions result in a number of mistakes being made. An example is the use of contextualising the wrong lean manufacturing ideal to a manufacturing process that it is being used by the organisation or assuming one tool of lean manufacturing can be applied to several different processes without contextualizing the tool that is being used to the sector in which it is being used (Bhamu and Sangwan, 2014). A lack of education on the part of management can also mean that the wrong processes are eliminated and defined as a wasteful process and, thus, require more input from employees. To accommodate for this error, employees, who performed those processes, are retrenched, and those that are left are learned employees who will ensure the maximum reduction of waste and defects. Employees grow discontent and resentful towards lean manufacturing and see it as a hindrance to their job and grow insecure for fear of not being able to perform at the level that is required of them and are, thus, reluctant to adopt it as a strategy for how they perform their tasks at work (Yang and Yu, 2010)

The effort of implementing lean manufacturing has also proven to be tenuous on companies in terms of the amount of effort required (Mwacharo, 2013). The study conducted by Bhamu and Sangwan (2014), which looked at 209 research papers, concluded that employees lost interest in lean manufacturing due to the extensive training and education programmes on the application of lean manufacturing. Consequently, employees began to see these programmes as a mundane and unnecessary factor to how they were meant to carry out their jobs and saw it as a loss of productivity with all the time it took to learn about the programmes. Similarly, Radnor et al. (2006) concluded that many organisations were under the misconception that it was for employees to first learn how to implement lean manufacturing as the first step and then gradually introduce it into how a business operates. This belief was wrong as it contributed to the failure of lean manufacturing within that organisation as it is management that must first learn the practical application of lean manufacturing to business operations before it can be applied as a manufacturing process. Thereafter, lean manufacturing should be conceptualized as a process that is introduced to employees (Ruiz-deArbulo-Lopez-Fortuny-Santos and Cuatrecassas-Arbos, 2013).

2.7 An Overview of the Toyota Production System

Lean manufacturing came into existence as a result of Toyota's attempt to maximise the efficiency on their production line. The Toyota Production System has since lead to the revolution of manufacturing and all processes associated with manufacturing (Woll, n.d). According to Thun, Druker and Gruber (2010), the Toyota Production System has two central approaches; the first concept is the "Just-in-time" approach which can be implemented through the use of practices that are efficient and centralize on making all processes in production less wasteful (Spear and Bowen, 1999). The second approach in the Toyota Production System is the "respect for humans" system which centres on all movements and activities being done by workers that add value to the manufacturing of a product; if no value is added by that movement or activity, it is considered to be a waste (Fujimoto, 2012).

According to Spear and Bowen (1999), there are four guidelines to which the Toyota Production System abides. The first is that all work is done in accordance with the context of the content it is meant to produce and is done in a contextual sequence of events, done within a marginalized amount of time and achieves a standardized outcome which ensures that, if a deviation occurs, it is immediately identified and dealt with accordingly. The second guideline ensures that employees are aware of all team members within a process and are aware of the role they each play and the support that they are meant to provide for one another in relation to the production process. When and how it is done, is the duty of the suppliers to ensure that all parts issued to an employee for a process are correctly catalogued and accounted for (Fujimoto, 2012).

The third principle, according to Spear and Bowen (1999), is that manufacturing of every product and service being delivered towards the completion of the product has a specified routine that is followed and ensures that there is a specific set of employees involved with a specific process and a specific amount of resources that are required for the completion of the product. The final principle states that any improvements done to the processes and to the work routine of an employee, as well as any improvements done to the management of resources, should be done with the use of a thoroughly researched scientific method of improvement that is based on previous research and literature and ensures that there is a greater percentage of waste elimination achieved with the whole process being carried out by the employee who carries out the process under improvement and is supervised by a member of leadership (Thun, et al., 2010).

In the Toyota Production System, all business systems are seen as multi-processes that are capable of carrying out multiple operations simultaneously, thus improving on the layout of production and increasing productivity (Spear and Bowen, 1999). Employees are also capable of performing more than one task within any given operation. All errors are seen as a form of waste with all employees and all members of management being aware of the required level of quality that the products being manufactured must have, as one of the core concepts to the Toyota Production System is the quality of the product being manufactured (Fujimoto, 2012). Thus, the Toyota Production System, upon which lean manufacturing was based, still places emphasis on the same values on which lean manufacturing is based (Thun, et al., 2010).

2.8 Implementing Lean Manufacturing

Lean manufacturing is fast becoming the preferred method of manufacturing (Kahlen, Flummerfelt and Siriban-Manalang (2012). There is, however, a lack of effectiveness in the lean manufacturing systems being implemented due to a lack of guidelines on how to go about implementing lean manufacturing (Ndou, 2009). Andersson (2007) found that the reason for the existence of this shortcoming is the lack of in-depth knowledge that exists on seeing past the technical applications that lean manufacturing has and regarding it as a way in which business can be carried out on a daily basis. The reason any organisation chooses to implement lean manufacturing is for the benefits it provides by way of improved responsiveness and flexibility in business strategies as well as a better educated and skilled work force, resulting in the improved quality of the product being produced (Kahlen, et al., 2012). In order for the implementation of lean manufacturing to be successful, implementation must begin with management before working its way down to the actual manufacturing process (Karim and Arfuz-Zaman, 2013).

Ndou (2009) believes that, for lean manufacturing to be successful, an organisation needs to focus on the long-term results yielded by lean manufacturing, as it takes time for lean manufacturing to gain traction within a business for the success gained to be consistent and for the organisation to yield sustainable improvements and benefits for the period of time that it remains implemented. Andersson (2007) believes that, for lean manufacturing to be successfully implemented, it needs to be seen as a way of thinking and not just as a set of components aimed at improving the manufacturing process. A change in thinking is required from both management and employees alike in order for lean manufacturing to prove effective for that organisation. Lean manufacturing should not be seen as a process with a point of closure but should, instead, be seen as a continuous process consistently working towards improving how a product is manufactured (Ondiek and Kisombe, 2013). When an organisation implements lean manufacturing, it should ensure that employees understand why it is necessary and how it works and are not resistant to the changes represented by lean manufacturing to ensure its effective implementation (Kahlen, et al., 2012).

In order for lean manufacturing to be implemented effectively, both management and work floor employees will require a new level of education and skills that are required for lean manufacturing to be obtained (Gaw, 2007, cited in Ndou, 2009). It requires an in-depth examination by management into the level to which lean manufacturing needs to be implemented to ensure that it improves on existing processes of manufacturing, which require facilitating change within the workplace of employees and adjusting what is required of them in accordance to this change (Oon, 2013). This change ensures that an organisation stays competitive within the industry and is continuously innovating on the ways in which lean manufacturing is implemented and improved upon to ensure that the quality of the product being produced is at its best (Andersson, 2007). Kahlen, et al., (2012) found that implementing lean manufacturing at grass-roots level, which is initiating the process with employees first and then management, has short periods of success due to the lack of motivation provided by management for employees to consistently use the lean manufacturing process.

There are no set rules or guidelines for an organisation to follow on how to implement lean manufacturing, and it is the responsibility of management to choose the steps required for the successful implementation of lean manufacturing within an organisation (Ndou, 2009). It is for management to lead the way forward for its employees and take the initiative of providing a way for lean manufacturing to be implemented; which can be done by following the examples of companies that have implemented lean manufacturing in the same industry and adapting a strategy that is customised to the needs of the business (Andersson, 2007). Tinoco (2004) is of the opinion that there are three stages to implementation, the first being the demand stage in which the needs of the customer are incorporated into the manufacturing process and creating a pattern on how work is done to ensure the entire process of production is transparent to employees and management alike. The second stage, according to Tinoco (2004), is the flow stage in which the organisation produces a specific amount of the product being manufactured in a specific amount of time to meet the needs of the customer, and the final stage is the levelling level in which the work is spread out through a set period of time (Tinoco, 2004).

2.9. Principles of Lean Manufacturing

In order for lean manufacturing to be successful, the necessary principles, which are crucial components to the lean manufacturing system, have to be taken into account, as these principles provide an improvement in the quality of work being carried out, as well as the product that is manufactured (Isaacs, 2012). In order for lean manufacturing to be effective, old and out-dated rules must be abandoned, the way in which business is conducted within a manufacturing organisation must be changed, and it must thoroughly immerse itself in the principles that are a part of lean manufacturing (Jozaffe, 2006). The principles of lean manufacturing ensures that the lean manufacturing process of an organisation runs efficiently and all cost effective measures are put into place, ensuring that the high quality of the product is being maintained, which then lessens the effort and time put into a product and the process of manufacturing, while still ensuring that nothing related to the quality of a product changes and the efficiency of how a business is run is not impacted on negatively (Poppendieck, 2002).

There is a great deal of discussion around the following principles of lean manufacturing which are considered as vital to successfully implementing lean manufacturing, according to Anderson (2006, cited in Vahed, 2012):

i. The first core principle of lean manufacturing is providing an understanding of customer value which considers the perception of the customer of what is valuable to be vital in the production process (Jozaffe, 2006);
ii. The second principle is value stream analysis, which is a review of the processes that are involved in the running of a business and determining which processes should be kept and/or modified as they add value to the production process and which can be seen as a waste (Anderson, 2006, cited in Vahed, 2012);
iii. The third is flow, which ensures that the manufacturing process and business practices are run smoothly and efficiently with no break within the manufacturing process (Poppendieck, 2002);
iv. The fourth principle is pull, which is stock produced in accordance with the needs of the customer; and

v. the final principle is perfection which is the consistent improvement of processes required by the business to function properly (Jozaffe, 2006).

Understanding customer value impacts on the prioritization given to a process and project regarding the conceptualisation and creation of a product, as the benefits a product is meant to have and the needs it is meant to fulfil are those of the customer (Duiker, 2014). Through understanding, an organisation ensures that there is no wastage of resources or wastage of time and costs that go into a product and ensures that the quality of the product meets the standards of the customer, which is done by only including processes and operational strategies that add value to the product being manufactured (Mostafa, Dumrak and Soltan, 2013). The interaction between a customer and employee is also integral in determining the value of human interaction with the manufacturing process. Jozaffe (2006) found that how effectively and efficiently a client was served by an employee played a major role in the perception the customer had of the organisation and how business was conducted, which, in turn, influenced how the customers perceived the quality of the product they received and determined if it met what was required by the customers.

After analysing and recognizing the needs of the customer, the next principle, i.e., value stream analysis, ensures that the value of a product is obtained (Vahed, 2012). Consequently, an organisation is able to effectively meet the needs of the customer while cutting down on unnecessary cost and reducing the amount of resources that go into making a product by only selecting the materials that are deemed as necessary (Poppendieck, 2002). The value stream, according to Jozaffe (2006:20), is "the set of all the specific actions required to produce a specific product". This is achieved with the use of consistently identifying and solving problems as they occur through the production process and the management of information as it goes through each process and is passed on through the manufacturing line, from the process in which raw materials are utilized to the supply chain, all of which is done to ensure that the quality of the product is maintained till it reaches the customer (Duiker, 2014).

Flow as a lean manufacturing principle focuses on ensuring that there is a continuous movement throughout the entire manufacturing process and that there is a constant flow of the product in accordance with the needs of the customer, in contrast to moving large quantities of a product and having a surplus, that is, the amount of stock that is not sold, which is moved into an inventory (Vahed, 2012). Mostaffa et al. (2013) found that, stock kept as inventory, loses the quality it originally possessed prior to being produced, and this then decreases the monetary value for which it can be sold and ends up as a waste of the resources and effort that went into producing it. If there is a constant flow to the supply chain and the product reaches the customer without going into inventory, a product retains its value and it ensures that there is no inventory as the amount of product being produced is the amount required by the customer (Poppendieck, 2002). Flow is then the assurance that the value of a process is maintained and that the processes involved in manufacturing a product is continuous and does not have a break point at any given stage of manufacturing such a system ensures that waste is kept at a minimum and processes and resources of value are maintained (Jozaffe, 2006).

Isaacs (2012) found that pull is a continuation of what the principle of flow sets out to achieve. Therefore, pull is requirements a product must meet in accordance to the need of the customer. The time involved in the manufacturing process is reduced and the efficiency of the manufacturing process, as a whole, is effectively increased as a result (Vahed, 2012). Pull, however, is not only applicable to the technical processes involved in the manufacturing process but can also be applied to the way in which business is conducted and how employees are motivated (Jozaffe, 2006). According to Duike (2014), it can also be seen as a way of thinking in which a team of employees is motivated towards ensuring that the quality of a product is of a high standard, and is dependent on their ability to look past lean manufacturing as only an operational process and grasp lean manufacturing as a way of doing business and a way of thinking. Poppendieck (2002) also found that it is the type of behaviour and motivation that an organisation is able to pull from its employees that determines the overall outcome of a product.

Perfection is the final principle and ties the above-mentioned principles together because, according to Arnheiter and Maleyeff (2005), it is the constant assurance and inspection of a manufacturing process that ensures all resources and processes that add no value to the manufacturing process remain eliminated. Moreover, processes that are involved with the manufacturing process are continuously modified and improved upon to ensure that the time, cost and effort involved in the manufacturing process are in a perpetual state of improvement to ensure that the customer receives the highest quality of a product that an organisation is able to produce. Jozaffe (2006) is of the opinion that the quest for perfection in a manufacturing process ensures that an organisation is always seeking to improve itself and ensures that everyone, who is involved in the lean manufacturing process, has access to every process and aspect involved as a means of total transparency to ensure that the identification of how a system or process can be improved is done more efficiently, thereby ensuring a continuous improvement to the ways in which the needs of the customer are met.

2.10 Tools of Lean Manufacturing

2.10.1 Elimination of Waste

Karlsson and Ahlstrom (1996) define waste as any aspect in a company and within the manufacturing process that does not add value to the product that is being produced and is an aspect of a product or resource used in manufacturing the product for which the customer is unwilling to pay. Douglas, Antony and Douglas (2015) share this view as they are of the opinion that the value that goes into a product is defined by the customer and what the company sees as a necessary component for the product that is being manufactured. The original concept for waste was termed as “muda” and was defined as any activity and process that provides no real significant contribution to the process of manufacturing a product and uses resources without providing a valuable input to the process at hand (Perreria, 2008). There are eight key areas in the manufacturing process from which waste can be removed. These areas add value to the manufacturing process and will be discussed in the course of this section as well as the concept of Kaizen and the relation it has to the removal of waste.

AbuShaaban (2012) looks at the waste of transportation as any kind of movement within a company that does not provide a significant contribution to the creation of a product. This includes generally overlooked forms of movement such as the transport of production materials and resources from one stage of manufacturing to another as the goal of the reduction of transport waste should be for the end point of one phase of manufacturing to be used as the starting point of the next phase of manufacturing, thereby reducing time wasted in one cycle of manufacturing a product. To reduce time that is wasted in transporting parts from one station of manufacturing to another, Sternberg, Stefansson, Westernberg, BorjeafGen, Allenstrom, and Nauska (2013) found that the layout design of manufacturing could be readjusted to minimise the transport between the different stages of manufacturing and create a cell-based design which the resources and materials required for the end product have a logical and efficient flow from one area of work to another. Unnecessary movement by employees to transport items and resources has also been defined as a waste by Sternberg et al. (2013) and the transportation of the product to the supplier if long and unnecessary routes are involved in transport.

Inventory is defined as a waste because the storage of parts and excess stock of the product being manufactured only decreases the value of the items being stored as they are subjected to forms of erosion and depreciation (Perreira, 2009). Perreira (2009) further states that inventory loses value instead of gaining it as stock, that is kept in inventory, loses quality assurance. Moreover, parts used in the manufacturing process lose reliability and function in the work that they are meant to perform, thereby increasing waste in the form of time and wasted resources (Perreira, 2009). Inventory can also be seen as work that is done gradually over lengthy periods of time and not completed immediately; it can be seen as a waste because it wastes the capital that is invested into the completion of manufacturing but also camouflages other problems that may occur during manufacturing as a result (Johns, Crute and Graves, 2002). Douglas et al. (2015) found that too much work stored for completion at a later date leads to the back up of work that needed to be completed. This increases the time required for the completion of manufacturing and increases the time required to complete essential tasks and tasks that still need to be completed. Karlsson and Ahlstrom (1996) found that it is better to remove the reasons for having an inventory before eliminating the inventory itself. Once this is done, the gradual depletion of the inventory ensures it eventually becomes unnecessary.

Motion has been found to be wasteful as it reduces the productivity of all employees and departments involved in the manufacturing process. Furthermore, the difference between waste of motion and waste of transport is that waste of motion is concerned with the human aspect of movement that is required for the manufacturing of the end product (Johns et al., 2002). Waste of motion is when there is too much time wasted by an employee to get from one point to another during his/her work process and includes activities that result in a loss of productivity on the part of the employee (Perreira, 2009). If an employee is able to effectively reduce the movement required for the manufacturing process, it also results in the reduction of time and energy that is required of an employee to complete a task. Such a reduction increases the rate of productivity that an employee is capable of increasing the efficiency of the manufacturing process (AbuShabaan, 2012). While it does not provide much of a significant change to the elimination of waste in comparison to other waste elimination processes, it does assist in increasing the efficiency with which employees complete their job and assists in ensuring a fast line of manufacturing (Douglas et al., 2015).

According to Perreira (2009), waiting is a form of waste as it results in a total reduction in the manufacturing process on all levels as every process involved in the manufacturing of a product is dependent on one another for a smooth and efficient flow of manufacturing. Thus, if there is a delay in one process, it proceeds to stall the flow of manufacturing which, in turn, creates a wait period before these processes are able to function again. If any point of the manufacturing process malfunctions, this results in a wait period which leads to waste of production time and increases the cost that is involved with the manufacturing process as well as wasted resources. Hence, to compensate for the wait period that has occurred, it is vital for companies to ensure that all technological equipment and machinery involved in the manufacturing process are well maintained on a regular basis (Sternberg et al., 2012). The wait process involved in the chain of supply of creating the end product to ensuring it reaches the retailers selling it has also been found to be a waste as it does not add value to the final processes of manufacturing and delays the product being received by the customer (Douglas et al., 2015).

Over production can be thought of as one of the more pertinent forms of waste as this is the manufacturing of more stock than is required by the customer, which could occur as a result of manufacturing products for which there has been no recorded need, or producing more of a product than the amount ordered by the customer at that particular moment in time (AbuShabaan, 2012). Over production also creates other forms of waste, as excess stock requires the creation of a larger inventory and an excess amount of transport is required to move the stock from the end of the manufacturing line to be stored in inventory. Moreover, over production requires more attention and effort from employees, thereby increasing the waste of motion and is often involved in the delay of manufacturing products that are actually required by the customer, thereby creating the waste of waiting (Perreira, 2009). It can also lead to defects in the product being manufactured as it decreases the quality of products in the manufacturing process through oversight of the quality of the product that is being produced which is the result of the excess stock being manufactured, all of which leads to an overall increase in the waste being experienced by a company (Johns et al., 2002).

Over processing is the result of doing more than is asked for by the customer. That is, more effort, time and cost go into manufacturing than is required. As a result, resources and costs are wasted in the manufacturing processes resulting in customer dissatisfaction and the company's wastage of resources and processes in the manufacture of the product (Douglas et al., 2015). It can result in using more processes and stages than are required to manufacture a product. Therefore, there is a higher level of quality of the end product than is actually required, all of which culminate in an excessive amount of wasted resources and materials.

Effort is required on the part of employees at every stage of manufacturing, as well as all technical processes that are involved in the manufacturing process (Perreira, 2009). Over processing could also be the result of a number of reasons, such as equipment that may have malfunctioned or processes that have been rendered ineffective as a result of lean manufacturing. It could also be due to a lack of effective communication between the different stages involved in a manufacturing process and not properly researching or adhering to the needs of the customer (AbuShabaan, 2012).

On the opposite end of the spectrum, defects can be defined as any processes or material that are below the level of quality that is expected by customers. This could be as a result of shoddy workmanship on the part of employees or a technical oversight in the manufacturing process (Duiker, 2014). A defect, in terms of manufacturing a product, can be defined as a fault found within a product that affects the quality and purpose that a product is meant to serve in relation to the needs of the customer. Poor quality could result in the rejection of the product by the customer which could result in a loss of profit for the company, the incurrence of unnecessary cost and wasting resources and manufacturing processes (Johns et al., 2002). A defect could occur as a result of accidental excess stock that was ordered by the customer through the supply chain process. This results in a defect in the stock produced because of the excessive amount that was produced. Quality needs to be managed throughout the manufacturing process to ensure that defects do not occur and negatively affects the level of quality that is produced by the company, thereby reducing the level of waste that occurs in the manufacturing process (Douglas et al., 2015).

The final kind of waste is the lack of utilisation of employee creativity in the manufacturing process, which Sternberg et al. (2012) define as the utilisation of the employees in a company as a means of improving and reconceptualising the manufacturing process to improve how lean manufacturing is implemented within a company. This entails ensuring that the ideas and concepts created by employees are heard and applied appropriately within the area it intends to improve. Not utilizing the creativity of any given employee limits the effect that he/she is capable of having within the company and on the manufacturing process (Perreira, 2009). Being a fairly recent discovery, there is no quantifiable method by which this waste can be measured. Therefore, it is the duty of the management of a company to ensure that all ideas from employees are heard and considered carefully while taking into account the other forms of waste and ensuring that any idea used produces a minimum amount of waste and maximises customer satisfaction and product quality by utilising the workforce of a company, thereby ensuring that the employees feel appreciated by a company (Sternberg et al., 2012).

Kaizen is a process that is frequently utilised in the elimination of waste. According to Nhlabathi (2013), kaizen is the elimination of waste from any given process within manufacturing and emphasizes a reduction in costs while removing processes that add no value to the manufacturing process and empowers employees of the company with the tools required to identify areas that can be improved upon and change them accordingly. It is imperative that the people who are directly affected by any changes be involved in the process. Kaizen also promotes the continuous improvement of the manufacturing process and follows a set of simple ideals, such as well thought out and constructed process, which, in turn, yields good results and the belief that significant results in the reduction of waste is the result of minor and gradual changes made by a manufacturing company over a period of time (Shah and Ward, 2007). Therefore, one can conclude that Kaizen is a philosophy by which business can be carried out in an attempt to ensure the removal of total waste from within a company and is done so with the use of resources that come from within a company and are not sourced externally (Duiker, 2014).

2.10.2 Continuous Improvement

Continuous improvement can be seen as vital to the success of lean manufacturing within a company. This tool of lean manufacturing emphasizes and ensures the involvement of all employees involved in the process of manufacturing and ensures that all employees work together towards improving the manufacturing process and is continuously monitored to identify further areas of improvement (Karlsson and Ahlstrom, 1996). This concept ensures the quality of the product is of the highest standard and efficient service is provided to customers. Moreover, it ensures a smooth and well maintained flow of the functions required by a business on a daily basis. Vahed (2012) states that continuous improvement is a component of lean manufacturing that promotes a culture of values that enhances the dynamics of the functionality of a business and must be applied to all aspects of a how a business is run. Ondiek and Kisombe (2013) found that continuous improvement also works towards the reduction of cost in terms of services and products and maximises the profit that a company is able to make and ensures the full utilization of activities and processes that add value to the product being manufactured.

Sim and Rogers (2009, cited in Vahed, 2012) state that continuous improvement is a culture of sustainable enhancement that affects all activities and processes. It seeks to improve these processes by increasing the quality of a product and increasing the rate of delivery as well as enhancing productivity and customer satisfaction. Continuous improvement decreases the time used in the manufacturing process as well as reduces the cost that goes into the manufacturing process and reduces the waste of materials. It is a concept that Vahed (2012) believes should be applied as both a philosophy of business and manufacturing process, as it should enhance how employees perceive carrying out tasks and duties and requires total commitment from employees in order to be successful with a business. Makhomu (2012) found that the success of continuous improvement, as a way of doing business, relies on using it as a tool to enhance how duties are performed. An example provided by Makhomu (2012) is ensuring that a work space is kept neat and tools are kept in order of necessity. On a higher level within a business, it can be applied to all administrative and creative processes to increase the level of productivity of the business as a whole (Lee-Mortimer, 2008).

As continuous improvement involves employees actively tasked in the activities being improved, it also allows for the opportunity to empower employees in the manufacturing process to make decisions related to the improvement of the manufacturing process. Vahed (2012) found that the experience an employee has with a given stage in the manufacturing process allows for the employee to provide valuable input on which processes should be scrapped as they provide no value and which processes should be prioritized and improved. Similarly, Lee-Mortimer (2008) discovered that, by allowing employees the opportunity to reorganize the processes involved in the manufacturing line, it created a better flow of communication between employees working on all aspects of manufacturing and allowed for a better flow of materials from one stage of manufacturing to another. There is no end to using continuous improvement as a tool for the processes involved in lean manufacturing; it is then the duty of everyone involved to ensure that processes are continually examined and improved to ensure that lean manufacturing is a success within the company, thereby achieving the primary goal of continuous improvement (Makhomu, 2012).

2.10.3 Just-in-Time

The lean manufacturing tool of "Just-in-Time (JIT)" is one of the most practical tools of lean manufacturing and significantly impacts on the productivity and efficiency of a production line (Sangwan, Bharnu and Mehta, 2014). As a system, it can be defined as the precise and effective time management of when a product is manufactured, in the necessary quantities in the allotted time of manufacturing and is delivered and distributed at the appropriate time (Kim, 1985). As a way of managing the business, it can be defined as a philosophy that places emphasis on constantly improving how efficiently business is managed and conducted and ensures that all activities that provide no benefit or value to business processes are removed, thereby reducing the costs involved in conducting business, as well as improving on product quality and the overall performance of employees as a means of stimulating innovation within the work place (Brox and Fader, 2002). Both these forms are applicable within any business that has chosen to use lean manufacturing as a way of carrying out business and the overall concept of just-in-time ensures that all processes and resources that can be seen as waste are removed and there is a continuous flow of improvement with the processes still in use (Mund, 2011).

2.10.3.1 Just-in-Time as a business philosophy

One aspect that management attempts to apply after implementing lean manufacturing is the concept of just-in-time which is applied to all work-in-progress inventories. This means that all processes that require completion over a gradual period of time are minimised as much as possible or removed entirely, as inventory is a great expense due to the loss it causes to productivity and incurs additional expenses as a result of the additional and unnecessary stock that is produced and stored. Just-in-time reduces these costs and the need for an inventory (Alles, Datar and Lambert, 1995). Just-in-time, as a process, ensures that, if there is a need for an inventory, it is effectively controlled and managed to ensure that it has no additional impact on business in terms of additional expenses incurred as a result of all inventory-related processes and resources (Steyn and du Toit, 2010).

Brox and Fader (2002) discovered that the process of just-in-time has a focus on the removal of waste within specific areas of a company, such as the waste incurred as a result of over manufacturing the product of any specific business and all waste that is involved in the transportation that occurs in a business, as well as the waste that is a result of the inventory possessed by a business. This is also applied to the human resources and administrative aspects of how business is carried out, as just in time allows for an improved quality of the information available regarding the manufacturing processes as a result of the reduction it allows for the waste that is removed during all processes of business and increases levels of productivity in all aspects of a business required to function (Kim, 1985).

The just-in-time system also encourages employee participation in the processes that are required for just-in-time philosophy to be implemented effectively and encourages employees to voice their opinion in regards to what activities and resources can be seen as a waste and do not add value to the manufacturing process (Brox and Fader, 2002). Alles et al. (1995) found that, increasing the involvement of employees with the process decisions involved in lean manufacturing, assists in decreasing the levels of inventory within a company. As a result of lowered inventory, there is greater transparency available for the stock that is available and a greater ability to manage stock as it comes in. Alles et al. (1995) found that this allowed for employees to be rewarded for their improvements because of the cost reduction made possible by a smaller inventory.

2.10.3.2 Just-in-Time as a Manufacturing Tool

Just-in-time within the manufacturing environment assists in the reduction of lead time which is the time required for the entire process of manufacturing to be completed, by reducing lead time. It allows for a quicker response to the needs of the customer which allows for companies to become more customer orientated (Ward and Zhou, 2006). Just-in- time ensures that all the manufacturing processes are controlled and reconceptualised to ensure that the product required by customer is manufactured in the exact amount that was requested within the stipulated time frame, thereby ensuring a deficit of wasteful processes and resources. Consequently, it ensures that the manufacturing functions are in accordance with the demand for the product and acts as a form of management when there is a variety of products being manufactured according to the needs of the customer (Yavuz and Akcali, 2007).

Kim (1985) classifies just-in-time as a pull system which refers to the categorical organization of the manufacturing process as the end product created in one manufacturing process is then used as the starting point of another and continues in this manner until the final process in which the end product is completed. For the adoption of just-in-time processes to occur within an industry, there are a number of programmes and algorithms that need to be introduced to accommodate the changes that need to occur for just-in-time processes to run efficiently (Yavuz and Akcali, 2007). The requirements include an entire review on how a company runs on a day-to-day basis and how these processes can be improved or removed as a result of the just-in-time approach. Therefore, the company should fully incorporate just-in-time practices for it to be successful (Ward and Zhou, 2006).

The success of just-in-time, as an operation approach used in manufacturing systems, depends on how well employees are able to work as a team and have a grasp on just-in-time as a lean manufacturing component, thereby ensuring that all processes are run efficiently and the time required for the completion of each process is reduced to the appropriate amount (Kannan and Tan, 2005). Just-in-time also ensures that the quality of the end product is effectively managed through the control and maintenance of the time that goes into each process and ensures the prevention of error through the consistent maintenance of resources and activities, thereby minimising the likelihood of waste and ensures that emphasis is placed on the expectations of the customer rather than the inventory of the company (Kim, 1985).

2.10.4 Zero Defects

Quality is an aspect that is not applied to the product being manufactured but is also applied to the process of manufacturing to ensure that an efficient and high level of productivity is maintained as the manufacturing process progresses. Thus, it is of utmost importance that all products and parts involved in the manufacturing process are without any sort of defect (Karlsson ad Ahlstrom, 1996). This is the essence of the zero defects component of lean manufacturing as it is the continuous effort made by a company to ensure total quality in the manufacturing process. There are several methods that can be used to ensure that a company is constantly adapting to new technological innovations and making progress in the implementation of lean manufacturing according to the context of the manufacturing process of that specific company, thus ensuring the quality of the product being produced and that the manufacturing process remains without any kind of defect that would affect the process negatively (Rahman, Lassirihongthong and Sohal, 2010).

Part of ensuring that a system has zero defects is by ensuring that the lean manufacturing system of a company moves towards a greater level of process control which refers to the total control and assessment of each process involved in manufacturing a product which is done by having complete awareness and understanding of every activity involved in manufacturing processes, thus ensuring quality of the process (Taggart, 2009). By doing this with every process that is involved in manufacturing guarantees that the parts involved in the manufacturing process are monitored, thus resulting in a marginalised probability of error. Therefore, defects do not occur or are minimized as far as possible and, to ensure that this is done effectively, all processes currently being used must be re-evaluated and adapted according to the principles and components of lean manufacturing to ensure that a level of zero defects is maintained (Tiwari, Turner and Sackett, 2007). A process called autonomous defect control is a process by which the assessment of manufacturing structures is carried out through the use of easily available effective measures that are also cost effective for the company in question. The inspection can be carried out by a member of management responsible for the process or through the use of a predetermined set of criteria (Taggart, 2009).

Karlsson and Ahlstrom (1996) found that there should not be staff who are solely dedicated to the assurance and assessment of quality and the management thereof, as it is the duty and responsibility of all employees and members of management to ensure that quality levels are effectively controlled and maintained so that an overall standard of quality is maintained throughout the manufacturing process. Anvari, et al. (2011) found that the duty of identifying a defect within the manufacturing process was the responsibility of employees who are involved in that particular process as it is the employees who are acutely aware of how each part in a manufacturing line is meant to function. Therefore, they are able to identify the defect that may occur at a quicker pace and greater degree of efficiency than designating a team of staff dedicated to the maintenance of quality management and quality control. This reduces the number of staff required for the designation of quality management. Moreover, as a result of the persistent examination and control of error marginalisation, the severity of a defect, should one occur, is reduced and the area required for repair is minimized (Cwiklicki, 2016).

To ensure that workers are not overwhelmed by their responsibilities regarding the repair and maintenance of defective parts, Karlsson and Ahlstrom (1996) found that the solution lay in placing the employees into teams for each process to maximise the productivity level of each process and minimize the defects that could possibly occur and allowed for the process to continue as part of the manufacturing line while the defective part was being repaired. This allowed for stages of manufacturing to be established and for tests to be performed as a way of better understanding the mechanisms of a process and how to better control it so that no defects occurred. This process, however, counteracts the elimination of waste within the manufacturing process as it creates a large amount of administrative paperwork that is meant to detail and log the test processes being conducted as a means of anticipating errors and defects and employing measures to ensure that they do not occur (Anvari et al., 2011). Therefore, zero defects, within a manufacturing process using lean principles, is reliant on employee participation in solving errors and ensuring that, while parts are being repaired, there is minimal effect on the manufacturing process as a whole (Cwiklicki, 2016).

2.10.5 Multifunctional Teams

Another component that plays an integral role in the success of lean manufacturing is the role of multifunctional teams in the processes that are required for the manufacture of the end product. According to Vienazindiene and Ciarniene (2013), multifunctional teams can be defined as a group of employees who are capable of performing a large number of different functions through extensive training and education to ensure that lean manufacturing, as a process, runs efficiently and is successfully applied in the context of the company. Multifunctional teams work best when placed in a compartmentalized, cell- based work environment structure to increase the flow of the manufacturing process and also assists with ensuring that the production line runs at a smooth and efficient pace. Each team is responsible for the fulfilment of all the tasks and activities necessary for the completion of that specific process which is required for the completion of the end product (Karlsson and Ahlstrom, 1996). For this to be at maximum efficiency, all employees working within a multifunctional team must be sufficiently trained and educated in the tasks they are expected to perform. However, conflict can arise between team mates, resulting in a loss of productivity (Pelled and Adler, 1994).

The aim of having multifunctional teams within the manufacturing process is to have a group of employees who have a varied skill set and have the capability to perform more than one task at a specific point within the manufacturing process. Soriano-Meier and Forrester (2002) found that this system works at a greater level of efficiency than having an employee who is only able to perform a set and singular task within the manufacturing process and serves no purpose towards the manufacturing process thereafter. Hence, employees within a multifunctional team have the opportunity to complete each task involved in their sector of the manufacturing process as the tasks within a specific level of the manufacturing process are rotated between members of the multifunctional team. Each individual is given the opportunity to perform a specific task as this increases the flexibility of employees and their capabilities and reduces the risk of error or waste within a manufacturing process as employees in a specific compartment are acutely aware of what should be used in a specific process and what should not be used (Karlsson and Ahlstrom, 1996).

An integral component to the success of multifunctional teams within lean manufacturing is ensuring that each employee in a multifunctional team has been sufficiently trained in the tasks they are required to complete within the manufacturing process as it ensures that employees have been equipped with the skills and insights required to work at a multifunctional level (Rahman et al., 2010). Training in the tasks employees are required to perform can be administered in a number of different ways. Karlsson and Ahlstrom (1996) found that employees benefit from practical engagement with the machinery required for the tasks they were meant to perform and were also engaged with tasks required for the maintenance of the equipment meant to be used, Soriano-Meier and Forrester (2002) found that educational programmes and skills workshops also proved to be effective and provided employees with a theoretical framework for the tasks they were meant to perform. Thus, tasks, previously handled by individual employees only, could now be performed by a multifunctional skilled employee as part of that specific process in the manufacturing line (Taggart, 2009).

There are challenges, however, that arise when attempting to form a multifunctional team. Karlsson and Ahlstrom (1996) found that some employees were reluctant to undergo training and education as they had grown accustomed to performing and carrying out the duties they were employed to do before the implementation of lean manufacturing. Thus, skills training and educational workshops had a decreased attendance and success rate. As a result of being accustomed to the people they originally worked with, employees placed in newly formed multifunctional teams proved detrimental to the success of multifunctional teams within a lean manufacturing context. As a result, hostility could arise between group members, thereby decreasing productivity (Pelled and Adler, 1994).

Another problem that also arose within multifunctional teams was the lack of effective communication between team members which had a negative effect on the performance of the team for the tasks that they were required to complete. This problem resulted in a decreased level of productivity for the manufacturing process as a whole (Vienazindiene and Ciardiene, 2013). The influence of conflict between team members also proved to be detrimental to intergroup relations. However, Pelled and Adler (1994) found that it also benefitted team members as it lead to better problem-solving techniques, a greater effectiveness in the ability of team members to adapt to their current situation and innovate concepts that improve the processes being performed. Thus, it takes all employees to be dedicated towards becoming multifunctional for it to be successful within a lean manufacturing environment.

2.10.6 Decentralized Responsibilities

Decentralized responsibilities is also a tool of lean manufacturing, It functions in accordance to multifunctional teams as it is in reference to the responsibility of ensuring the manufacturing line runs efficiently, so that the hierarchy that exists with traditional manufacturing companies falls away and the only form of higher level supervision is the employee responsible for evaluating and assessing the manufacturing process as a whole (Hook and Stehn, 2008). The hierarchy in question is the level of command that exists in traditional manufacturing companies in which the employees are under the supervision of a higher ranking employee who forms part of management and oversees tasks and activities being performed by each employee and reviews it in accordance with the level of productivity currently being maintained (Karlsson and Ahlstrom, 1996). There are levels of hierarchy that can exist within multifunctional teams if the size of the manufacturing company is too vast for there to be no form of management. However, in lean manufacturing, it is generally the multifunctional team who performs tasks that would normally have been done by a supervisor (Scott, Butler and Edwards, 2001).

Employees, who are part of a multifunctional team, often rotate leadership tasks between themselves which is made possible through extensive training that employees have received to prepare them for the roles they will play within the team as they no longer have a supervisor to whom they answer but are now in charge of tasks that were previously the responsibility of a member of management or higher qualified employee (Cochran, Eversheim, Kubin and Sesterhenn, 2000). However, Karlsson and Ahlstrom (1996) found that the task sometimes proved to be daunting for employees, particularly those who had become accustomed to working under someone else. As a result, these employees were reluctant to receive the necessary training and education required for them to complete the allocated tasks. This reluctance often resulted in a prolonged amount of time spent on training and a loss in time spent on being productive. Scott et al. (2001) found that this lack of hierarchy proved to be difficult to overcome. However, employees gradually became accustomed to making leadership decisions and having to manage the responsibility of a number of different supervisory tasks involved in the manufacturing process and perform at an acceptable level of productivity. The need for a higher level employee in charge of the process as a whole became unnecessary and thereby reduced the number of members of management involved directly in the manufacturing process.

Scott et al. (2001) believed that the reason for the slow-paced acceptance of the lack of hierarchy could be for a number of reasons with the first being finding employees with a suitable educational background and sufficient experience to undertake the role and perform the tasks that were necessary of them. Secondly, it was also challenging for employees to go through the training process as it required a lot of attention and time which frustrated many employees as they believed it to be a waste in productivity. Finally, after employees were trained, there was a challenge in finding an effective system of rotating tasks between members of a multifunctional team and finding a system and pattern that worked and allowed for each employee in a multifunctional team to perform all tasks. Karlsson and Ahlstrom (1996) found that, as a result of decentralized responsibilities; as many as two levels could be removed from the hierarchical systems that existed within manufacturing companies; namely, supervisors and preparatory workers. This finding increased interest by employees in the system of decentralized responsibilities and the number of employees willing to participate in training and take on supervisory tasks increased. Thus, the degree of effectiveness of a multifunctional team was determined by the skills and capabilities of its team members and their ability to perform the various tasks that were assigned to them (Scott et al., 2001).

Hook and Stehn (2008) found that the degree of training received by employees varied according to the capability of the employee. Thus, the degree of responsibility on each employee varied and this often leads to intergroup conflict and hostility as employees who take on more responsibility feel a greater sense of leadership over their colleagues. Such an unsavoury situation can be rectified by establishing an equilibrium in which employees working within a multifunctional team learn from each other and employees with a greater level of training assist their team mates in performing tasks and vice versa, which assists in resolving conflict and also decreases the probability of error. Thus, decentralized responsibility works to place employees in situations of leadership and allows for the removal of a hierarchical system within the work place (Karlsson and Ahlstrom, 1996).

2.10.7 Integrated Functions

Integrated functions is also a component related to multifunctional teams. According to Karlsson and Ahlstrom (1996:37), integrated functions can be defined as “the integration of different functions into the teams”, which means that any tasks and activities, previously performed by designated groups of employees that indirectly affected the manufacturing process, now became the responsibility of the multifunctional team who handled the processes on which activities have an effect.. This includes tasks such as the handling of materials involved in the manufacturing process planning and control the sequence of activities required by the manufacturing process and the assessment and evaluation of quality control. Consequently, the number of tasks and functions performed by any given multifunctional team increases and the number of employees required for these indirect tasks decreases as staff performing tasks that relate to technical support and maintenance can now be performed by multifunctional teams (Toralla, Falzon and Morais, 2012).

That the following problems arise when attempting to delegate all indirect tasks and responsibilities to multifunctional teams (Karlsson and Ahlstrom, 1996);

i. hesitance of employees responsible for the completion of these tasks to delegate them to a member of the multifunctional team due to the idea that the members of the multifunctional team may not be competent to complete the tasks that were expected of them; and
ii. the members within a multifunctional team were not willing to perform the tasks that they were required to as they felt that it was not a part of their duties and were hesitant to go through the skills and educational training required to perform the additional tasks and, thus, felt strained by the amount of work that was required of them.

Mund (2011) found that, despite the implementation of integrated functions now being performed by members of multifunctional teams, employees, who previously performed these tasks, were then reassigned to another department within the manufacturing process as many companies had a strict lay-off policy in place that does not allow for the instant and unwarranted dismissal of employees and found this to be counteractive to the lean manufacturing process. Abdullah (2003) found that initial implementation caused quality issues that require an increased number of employees to deal with these matters which result in waste of movement and an increase in the probability of an error occurring within the manufacturing process.

2.10.8 Vertical Information Systems

Vertical information systems is also a principle related to how efficient a multifunctional team is capable of being. It refers to the flow of communication within a lean manufacturing environment and aligns the performance of teams in accordance with the goals that an organisation hopes to achieve (Mund, 2011). The manner in which information is delivered is crucial to how effectively it is understood by members within a multifunctional team. The deliverance of information must be done in a manner that provides a continuous flow of information to employees working within a lean manufacturing environment as well as a manner that is systematic and timeous in its delivery (Aoki, 1986). The content of the information is also integral to the function it plays within a manufacturing environment as it can be strategic or operational in nature and this affects how it is interpreted and utilised by employees working within the lean manufacturing process. The way it is received by employees is also a determining factor in how it is used (Karlsson and Ahlstrom, 1996). By effectively comparing a vertical information system to a horizontal information system, Aoki (1986) was able to clearly map out the benefits that a vertical information system represented to a manufacturing organisation and changed how information was distributed and shared between employees and members of management.

Mund (2011) found that communication plays an integral role in the distribution of information within a lean manufacturing company as it influences how an employee develops the skills required for the tasks they are required to perform as well as the supervision being received by a member of management and influences how employees choose to engage with problem solving strategies should a technical difficulty arise within the manufacturing environment. Working within a lean manufacturing organisation allows for employees to learn as they work. The information being received from a higher level within the manufacturing process determines how effectively an employee is able to perform his/her duties. Vermaak (2008) found that an open line of communication and trust are key components to assisting employees in learning from the mistakes made within the manufacturing process and provide input on issues that concern the manufacturing process as a whole and provide methods of improving the manufacturing process within the parameters of lean manufacturing without the fear of being judged or criticized for their ideas. Morgen and Liker (2006) found that communication that is directly between an employee and a supervisor and done so through a direct method of communication provides the chance for feedback from supervisors and the testing of improvements to the methods being used in manufacturing.

There are different ways in which communication can be conferred to employees when using a vertical management system, Morgen and Liker (2006) found that visual forms of communication, such as news boards, allow for the communication of problems and concerns in a more transparent manner. They also allow for the direct and transparent communication of employees regarding any issues or problems that may arise during the manufacturing process. Visual forms of communication can be used to bridge the gap that exists between the expectations and reality of what actually occurs during the manufacturing process by providing transparency and awareness to problems as they arise. With the creation of more advanced forms of communication through the use of technology, Vermaak (2008) found that forms of communication, such as the use of emails or electronic documents, can also be effective within a lean manufacturing environment provided that they are received directly by employees and the changes that are communicated are addressed immediately. However, this form of communication is better utilised within an office environment as employees directly involved in the processes required for lean manufacturing may be unable to immediately address the concerns expressed in an email. This could create a backlog in productivity if a problem remains unaddressed (Mund, 2011).

There are two forms of information that must be relayed during the lean manufacturing process, according to Karlsson and Ahlstrom (1996). The first is information that is strategic in nature and concerns the entire level of productivity and goals that a manufacturing organisation hopes to achieve. Within every sector, it requires to function at an effective and efficient level of productivity. Strategic communication refers to decisions that have been made that impact on the process of lean manufacturing as time progresses and looks at the productivity and methods of improvement that can be implemented over a gradual period of time. It affects the more administrative and financial aspects of a manufacturing process, such as how a company performs financially as well as how a manufacturing process can be developed further. Information that is more operational in nature relates to how well a multifunctional team is able to perform within their area in the manufacturing process and provides criteria by which the performance of a team is measured. This is then communicated to the team it related to so they are able to use the advice given and improve their performance in accordance with the critique given as the performance of a team is measured on the quality of their work as well as how efficient they are in keeping to the schedule of production (Karlsson and Ahlstrom, 1996).

Aoki (1986) found that vertical information systems are more efficient than the traditional horizontal or hierarchical systems in how effectively the communication within a manufacturing organisation is carried out for a number of reasons;

i. within a horizontal information system, the capacity of management to identify and assess issues of concern and emergencies that may arise within the manufacturing process as all information is received directly by management which acts as the central point to which information is relayed;
ii. this limits management's capacity to intervene in arising crises and assist employees involved in the manufacturing process with solving issues as they arise and delays the manufacturing process as a whole; and
iii. in a vertical information, any issues of concern are communicated directly to the employees who are impacted by the problem. They are equipped with the knowledge to solve the problem as there is no part of the manufacturing process that acts as the centre of information being received and employees gain experience by solving the problems for themselves.

Within horizontal information systems, there is no growth for employees as they are only instructed by management on how to resolve a crisis and do not gain any experience in resolving a problem that arises, whereas in vertical information systems, employees are able to learn while doing (Mund, 2011).

2.10.9 Pull instead of push

According to Hopp and Spearman (2004), pull is a term referred to the manufacturing of stock in accordance with the needs and supply required by the customer. All material required for the manufacturing of the stock is scheduled accordingly and within the ratio that it is required to complete the order of the product. Push, on the other hand, refers to stock that is manufactured without consideration of the actual amount required by the customer. This means that there is no need to control the material being used and how it should be co-ordinated in accordance with the amount that is required (Hopp and Spearman, 2004). For most organisations that implement lean manufacturing practices, a combination of both is used to maintain a regular flow of stock and to ensure that, should the actual order be greater than the amount produced, there is surplus stock to serve as a means of meeting the demands of the customer (Karlsson and Ahlstrom, 1996). According to Mund (2011), there are two benefits that a pull system provides to the manufacturing process;

i. increasing productivity of the manufacturing line; and
ii. providing manufacturing organisations with a directive on reducing waste in the form of time and materials.

Pull, as a lean manufacturing principle, has been compared to “kanban”, a Japanese principle used in the Toyota Production System that provides a more efficient method of handling stock Kilpatrick (2003) explains that kanban works on rigidly planned stock that ensures the delivery and usage of material is done in a meticulous and organized manner. This runs through the manufacturing process with a total minimization of waste, where possible, and ensures that no work station is idle and is in continuous motion in alignment with the manufacturing process. Pull, as a concept, is dependent on the receipt of orders for the product being produced by a manufacturing organisation. This, in turn, determines the amount of materials required to be transported and used within the transportation process. By minimizing the time in which materials are delivered, a manufacturing organisation ensures that a product is produced in a timeous manner and within the time that it is required (Karlsson and Ahlstrom, 1996). This method of material processing and delivery ensures that no excessive materials are ordered by a specific process and then not made use of and that no time is wasted by employees in processing and delivering items from one process of manufacturing to another (Shah and Ward, 2007).

There are several benefits that are offered by pull as a system of delivering items. The first is that pull reduces the waste that is created during the processes involved in manufacturing by regulating the amount of waste incurred by any given process, resulting in a low mean level of waste created in the manufacturing process, thereby effectively reducing the manufacturing cycle times (Hopp and Spearman, 2004). As a result, by maintaining and regulating the level of waste within a manufacturing process, pull is able to achieve a greater output system that possesses a greater level of consistency and predictability, ensuring that all foreseeable errors are accounted for and countermeasures are in place to rectify them. It also ensures a higher and more consistent level of quality in the product produced as a result (Vermaak, 2008). An improved quality in the product manufactured is achieved through a dynamic operational system in delivering materials which results in a reduced queue line in the manufacturing process and a reduced level of defects in items due to the reduced time required for the examination and rework of products, which then creates an environment that is capable of achieving a higher level in the quality of the product that is being produced (Mund, 2011). Pull also leads to a reduced build up in the flow of the manufacturing process so that every process involved in the manufacturing process is controlled by ensuring a rigid examination of areas that have excessive waste and a specified input that initiates the manufacturing process (Hopp and Spearman, 2004).

2.10.10 Visual Management of Work Place

The visual management of a work place makes reference to a work environment in which all employees working within a manufacturing process understand that the physical space in which they conduct their work must be kept in an organized manner and managed by employees to ensure that their work is carried out in a secure and neat environment (Vermaak 2008). According to Naidoo (2012), there are six guidelines by which a conducive and efficient visual work environment is maintained and managed, namely; sort, set in order, shine, standardize, sustain and safety. These methods of visual management work in conjunction with one another so that a work place within the manufacturing process is kept neat and remains at a functioning capacity at all times (Naidoo, 2012).

These principles of visual management were founded on Japanese connotations that possessed the same meanings and values as the principles relevant to the visual management of a workplace in a lean manufacturing process where sorting refers to the removal of items that are not required for the completion of a manufacturing process and ensuring that it has been adequately disposed so that it does not become waste within the manufacturing process (Singh, Garg, Sharma and Grewal, (2010). It also ensures that all items or processes that slow down or prove to be tenuous to the manufacturing process are examined and removed from the workplace. All work is completed at an efficient pace with no obstructions to the completion of tasks and sorting. Consequently, there is a lowered risk of being hindered by unnecessary items, as Vermaak (2008) found within the South African manufacturing industry. Sorting, within the context of lean manufacturing, also ensures that all materials in use are evaluated in accordance with the purpose they serve and removed if they serve no purpose to the manufacturing process. A fully experienced and trained supervisor is required so that all work spaces are examined and readjusted on a regular basis to attain maximum efficiency within the work place (Mohammadi, 2010).

Set in order ensures that the flow of production within a manufacturing line runs at an efficient and organized pace to achieve maximum utilization of the work force and processes required for the manufacturing of the end product that is required by the customer. It also minimizes the loss of resources and time used in completing a process by ensuring that all tools and equipment necessary for the production process to continue are organized and in close proximity for use by the team in charge of that particular manufacturing process (Sanchez and Perez, 2001). Set in order, as a principle of visually managing a work space to meet the standards of a lean manufacturing organisation, also ensures that the workers who are first to arrive and set to work are the first to receive the necessary tools and materials required, thereby resulting in a faster and more efficient manufacturing process (Mund, 2011). This also enables all equipment involved in a particular process to be organized and arranged in accordance with the order of use. Hence, everything required for a specific process to be completed is done so in a time-efficient and organized manner (Mund, 2011). Therefore, all resources and equipment required for the completion of a manufacturing process are within easy access and to ensure that order is maintained, all work spaces are set and organized on a regular basis (Vermaak, 2008).

Shine is a term used to encompass all the cleanliness and tidiness aspects involved in the manufacturing process so that all work spaces are maintained and cleaned out of waste materials on a regular basis to avoid clutter within the work space (Vermaak, 2008). Shine can also be used as a method of inspection and assessment on machinery and equipment required for manufacturing processes which ensures a regular maintenance of machinery and the functions that they serve and that no equipment or machinery gradually deteriorates with regular usage (Vermaak, 2008). By maintaining a neat and organized work environment, employees ensure that all hazards are minimized and the work environment, as a whole, maintains a higher level of safety and organization. It also ensures that the work place is devoid of harmful materials and that it is a conducive environment to productivity on the part of employees involved in the manufacturing process and keeps employees satisfied within the environment in which they perform their daily tasks (Naidoo, 2012). This method ensures that everything is kept in such a state of order and is so properly organized, that any extraneous individual would be able to detect a fault or problem within a specific manufacturing process. Hence, all processes maintain a level of transparency during the manufacturing process (Sanchez and Perez, 2001).

Standardize is a principle that has a variety of applications to the manufacturing process and leads to an overall level of composure within the manufacturing process as a whole (Mund, 2011). It ensures that all the techniques used in manufacturing processes have been set and compared to the best standard practices available for that particular technique within the manufacturing process. All processes maintain an above average level of quality and consistency during the manufacturing process. Therefore, there is higher standard of work place organization kept by employees as a means of ensuring that all processes and activities are carried out at a maximum level of efficiency and organization and is consistently challenging employees to increase the levels of quality and efficiency of their work processes that are involved in manufacturing the end product (Mohammadi, 2010). Using a level of standards within the manufacturing process ensures that there is a consistent level of efficiency maintained within the organization of the work environment and how employees go about performing the tasks that are required of them (Vermaak, 2008). This then maintains a higher level of order within lean manufacturing processes. This level of order is maintained throughout the entire manufacturing process. Every piece of equipment or resource is properly set and organized and is not out of the place at any given time which would then reduce the rate of productivity and decrease the efficiency of the manufacturing line (Vermaak, 2008).

Sustaining the visual management procedures of a lean manufacturing process is a principle that ties up the functions served by previous principles of visual management. The purpose that they perform as sustenance within the context of lean manufacturing ensures that all equipment, machinery and work space required for the efficient and smooth flow of production are maintained and kept within optimum working order. Hence, the rate of productivity within the manufacturing process remains unaffected and is kept at a consistent and accelerated rate of functioning (Naidoo, 2012). It also eventually conditions employees into being able to perform maintenance tasks and necessary evaluations without being supervised or told to do so by a member of management or an employee with greater experience. This process of learning by doing allows for an increased skills set within employees as they familiarize themselves with the manufacturing process and identify potential concerns and technical difficulties as they arise (Mohammadi, 2010). Sustenance also involves the performance of examinations and assessments of equipment and manufacturing processes on a regular basis so that equipment is kept within a functioning state and changes or adjustments can be made within a manufacturing process should they be required. It also requires an extensive amount of training for employees so they are able to perform the relevant tasks to the best of their ability and have the necessary knowledge and skills to perform the adjustments to the manufacturing process should they be required (Vermaak, 2008).

Safety is a fairly new principle and ensures that all necessary protocols and hazard measures are in place so that the risk of being harmed physically within the workplace is drastically reduced for employees (Mund, 2011). The identification of potential risk factors and areas that pose a risk to the safety of workers is crucial in the improvement to the manufacturing process. Therefore, any substance or action that is identified as too great a hazard is identified, evaluated and either improved upon or removed entirely from the manufacturing process, thereby reducing waste within the manufacturing process and increasing the efficiency of the manufacturing process as a whole. These measures increases the safety that employees within their work environment and decreases the possibility of injury occurring within the work place (Sanchez and Perez, 2001). Protocols also provide safety to workers as it puts a set of guidelines into place should an accident or safety risk occur and provides a detailed description of what should be done within any given situation. Mund (2011) found that workers, who were trained and became familiarized with the safety protocols for their specific work space and all the machinery and equipment it encompassed, were able to respond at a quicker pace to an emergency situation and were able to perform the necessary tasks to reduce the risks without the guidance or supervision from a member of management. This allowed for workers to deal with work-related hazards and reduced the need for a specialized team to deal with potential work hazards.

Visual management within the work environment ensures that employees are consciously aware of their work space and everything that their work space contains at any given time. It increases the efficiency of the manufacturing line and increasing the rate of productivity. It also ensures that there is a checklist and guidelines in place so that the work environment is maintained at any given time and does not hinder the rate of productivity by reducing clutter and waste within the work space (Vermaak, 2008).

2.10.11 SMED Time Reduction

SMED is an acronym for Single-Minute Exchange Dies. It is a reference to an operations system that allows for the drastic reduction in the amount of time it takes for equipment to be changed over and strives to reduce the time required to change over equipment to singular units of time instead of the double unit it takes traditional manufacturing processes (Mokhalimetso, 2011). The goal of any SMED time reduction system is to reduce as many steps required for an equipment changeover as possible which means that these steps are performed while the equipment is still actively involved in the manufacturing process and attempts to minimize and improve upon the steps that cannot be externalized (Cumbo et al., 2006). There are several factors that influence the success of a SMED operations system within a lean manufacturing process as well as steps that need to be considered for the successful implementation of a SMED operations system. There are both internal and external factors to consider when implementing a SMED operations system, that is, processes that must be brought to completion after equipment has stopped functioning and processes that must be completed during the functioning of equipment (Rymaszewska, 2014).

There are several benefits offered by a SMED system, such as a faster production time reducing the stock turnover rate, which reduces the inventory of the final product that is in stock at any given time. As a result of the increased production and decrease in resources required to maintain an inventory level, customer demand is met at a faster pace and, therefore, increases the financial turnover being experienced by a company (Mund, 2011). Machinery used in the manufacturing process works at a faster rate as a result of the reduced turn over times. This results in the reduction of errors or technical difficulties that occur during the setup of machinery and equipment during changeover and reduces the need for test runs before a set of machinery required for the manufacturing process is put in place. Consequently, the quality of the manufacturing process is improved as it controls all operational processes involved in the manufacturing of a product (Rymaszewska, 2014). By reducing the changeover rate, it also allows for a more efficient set up rate and reduces the expenses that go into the setup of a manufacturing process. The easier enhanced set up process provides a greater level of safety to employees and reduces the chance of being injured during manufacturing and lowers the amount of skills required to complete a turnover process (Cumbo et al., 2006).

The following steps need to be considered before implementing a SMED time reduction operations system:

i. firstly,the evaluation and identification of the area in which the SMED time reduction will be implemented as an experimental run to determine the effectiveness it has for the manufacturing process as a whole and determining what equipment is best suited for the SMED time reduction process. This evaluates aspects, such as a long enough changeover, to be reduced by SMED time reduction, and allows for a variation in the rate of changeover achieved each time the equipment is changed. Thereafter, all employees required for that specific part in the manufacturing process is included and a baseline time is established to determine the area of improvement available for that specific process (Rymaszweka, 2014);
ii. the second element required for the changeover process should be evaluated and categorized in accordance to whether it is an external or internal factor and determines

what type of purpose a specific set of machinery serves in relation to the manufacturing process and the amount of time required to complete the process, all of which can be done while identifying the normal changeover process and taking note of both machinery that functions on its own and machinery that requires input from employees and determining the ways in which it can be improved (Cumbo et al., 2006);

iii. the third step requires the identification and separation of external factors from internal factors. This separates that processes that can be performed while machinery is running from processes that can only be done once machinery has stopped running. Hence, it can be determined whether a process is performed before or after the changeover of equipment takes place and not during which decreases the changeover time drastically. This includes aspects such as the examination and assessment of parts, the delivery and transport of machinery as well as the assessment of the quality of each process and cleaning and maintenance tasks that can be performed while machinery is functioning (Rymaszewska, 2014);

iv. the fourth step entails converting internal factors to external factors as it further decreases the turnover rate of each manufacturing process. This requires identifying each internal factor and determining whether it can be made into an external factor. It is measured in accordance with the cost required to change the process and the benefit it adds in terms of the time it reduces during the changeover process. This exercise can be done by modifying the function of each piece of equipment involved in the manufacturing process and preparing materials and resources in advance (Mund, 2011);

v. The fifth internal element that could not be converted to external factors must then be improved and the time required for the completion of each process be reduced as far as possible to ensure maximum utilisation of the SMED time reduction process. Each internal factor is identified and simplified to ensure that changeover time is minimized as far as possible to improve the changeover process as a whole. There are several ways this can be done, such as the elimination of motion involved in the manufacturing process, the elimination of the waiting for parts required for the manufacturing process to function efficiently and reducing the amount of tools required for the completion of a manufacturing process (Rymaszewska, 2014); and

vi. the final step ensures that all new processes and elements are noted and final improvements and adjustments are made before applying them to other aspects of the manufacturing process and determine which aspects and factors still needed to be completed and tested as a part of the manufacturing process. Thereafter, the process is repeated and tested to identify changes and improvements that can be made to the process and reduce the time required for the reduction of the changeover time of equipment (Cumbo et al., 2006).

2.10.12 Supplier Relations in the Context of Lean Manufacturing

The relationship between a supplier of a product and the company buying the product is often competitive as each party seeks to cover their own interests. Within a lean manufacturing organisation, there are several aspects and criteria that have to be met in order for the relationship between a supplier and buyer to be successful (Duiker, 2014). Macduffie and Helper (1997) found that for there to be a relationship of mutual trust and understanding between a supplier and buyer, it is the responsibility of the buyer to introduce lean as a concept to suppliers, and be aware of the cost that goes into the process of manufacturing the product that is being purchased. Each party should then focus on the greater value that can be achieved through an open and mutual relationship and not focus on competing against one another.

The price being offered by the supplier can be decreased through improvements made to the manufacturing process. A lean organisation can assist the supplier to becoming a lean organization which mutually benefits the supplier, who obtains a more effective method of manufacturing and the buyer receives the product at a reduced rate (Macduffie and Helper, 1997). The buyer can assist the supplier in ensuring that lean tools become integral components to the manufacturing process and assist the buyer in processes such as value stream mapping and visual management training to ensure that the manufacturing process used by the supplier is improved significantly to reduce the amount being paid by the buyer. If a manufacturing organisation chooses to make such investments in its suppliers, an environment of trust can be established, thereby creating the required conditions for its suppliers to succeed and reduce overall lead time, inventory and costs (Duiker, 2014).

The encouragement of a supplier towards becoming lean can be done by several methods such as motivating new ideas and innovations regarding the manufacturing process being used by the manufacturer and collecting data and information which assists in the problem-solving process and addressing errors that may occur in the manufacturing process

(Macduffie and Helper, 1997). Low cost solutions to aspects of the manufacturing process can be established through following a pattern of learning by doing that which allows for a supplier to learn about lean manufacturing processes by practising them (Macduffie and Helper, 1997). This also allows the supplier to be aware of the actual materials and staff required for the manufacturing process to function efficiently and for a product to be produced instead of what has been projected and create an efficient manufacturing process with a minimal amount of waste being produced at the end of each manufacturing process (Macduffie and Helper, 1997).

2.10.13 Customer Relations

According to Taj (2008), one of the most important principles in lean manufacturing is the possession of complete respect for all people and continuously improving upon relations with the different individuals who have a part in the manufacturing process, which includes individuals who purchase the product that is created by the lean manufacturing process, known as the customer or client of that organisation. The guidelines that need to be followed in dealing with the maintenance of conducive customer relations are similar to the guidelines that are used in the manufacturing process. They also work in reducing waste and improving the interactions between the customer and service employees and providing what is required by the customer at a faster rate. This improves the performance of the service department and maintains a consistent level of trust between customers and the employees with whom they interact (Escobar and Revilla, 2005).

In ensuring a good customer relationship there are several wastes that need to be avoided when serving a customer;

i. the first is ensuring that there is a minimal delay or no delay to the receiving of goods by a customer and waiting in a queue for a good that they have ordered; and
ii. the second is there should be a fair time constraint on the expectation time of when goods can be received by a customer to ensure that an organisation is able to deliver on goods within the time they have provided and do not fail to keep an agreement made with a customer (Escobar and Revilla, 2005).

Another form of waste is requiring a customer to repeat information that has been provided previously on an order that was made. This wastes time on the part of the customer and employee and no duplication of information should be made for an order that was already placed as it creates tension between the customer and employee, with the employee having to provide an extensive explanation of the information required and the customer growing frustrated by having to repeat information that was already given (Sarkar, 2007).

A poorly organized service counter can also result in a long wait for customers who have come to collect their order, and a poorly organized system of service can result in the loss of customers. According to Womack and Jones (2003), customers can become frustrated and take their services elsewhere. When the service counter lacks an efficient method of serving customers and logging orders, it results in a queue of customers being formed who are waiting to receive their order. Poor communication between a customer and employee can also be seen as a waste as it results in confusion between what is expected of the employee by the customer and what the employee understands the customer to need. This confusion could result in too much time being spent on attempting to clarify any kind of misunderstanding that may occur between the customer and employee and could create unnecessary tension between the employee and customer (Escobar and Revilla, 2005).

Value demand and failure demand have also been seen as crucial aspects to maintaining customer relations. Sarkar (2007) define value demand as the requirement of services by a customer while failure demand is the dissatisfaction of a customer as the organisation did not successfully fulfil the needs of the customer within a given time frame. Ensuring a mutually beneficial relationship between the customer and organisation can be established through the use of service employees with whom customers familiarize themselves with an open and trustworthy relationship, which allows for the employee to build other customer relations in a similar way as a result of the experienced gained from the previous customer (Womack and Jones, 2003).

Lacking stock of a product that is required by a customer can also result in the loss of customer interest. Such a lack can cause customers to look for the same product at other organisations. By not having the order placed by a customer can also cause the loss of customer patronage. Not having the correct items in stock required by the customer could also result in the waste of the products as it may cause inventory of the products that was not required by the customer (Sarkar, 2007). Behaviour from employees can also result in the loss of a customer. Escobar and Revilla (2005) found that employees, who were rude or surly in their demeanour, often had the highest rate of dissatisfaction from customer service surveys and resulted in a vast percentage of patronage being lost. By not keeping a functional relationship with customers acted as a deterrence to customer patronage, as no follow-up with customers and their satisfaction with the product often came across as disinterest on the part of the organisation and resulted in the customer losing interest in doing business with the organisation.

2.10.14 Knowledge Management

Most organizations, who implement lean manufacturing, only take into account the more technical applications of lean manufacturing and fail to see the extensive range that is covered by lean as a concept which can also be applied to knowledge management. Knowledge, according to Davenport (1998, in Dumbrowski, Mielke and Engel, 2012:437), can be defined as "a fluid mixture of framed experience, values, contextual information, and expert insight that provides a framework evaluating and incorporating new experiences and information". Within the context of a business, this can refer to the knowledge gained from experience and information and belongs to everyone involved with that specific organization where lean manufacturing knowledge is decentralized and flows between management and employees who both gain from knowledge and experiences that occur within a business (Skogmalm, 2015). For knowledge management to be successful within a lean manufacturing environment, it must be disseminated to all aspects within a business and be shared openly between employees and management. However, it does lack a systemic manner in which the information is disseminated and results in the loss of information (Dumbrowski, et al., 2012).

As a result of the extensive information that is available on the implementation of lean as a method of manufacturing implementation, many organizations involved in implementing lean manufacturing often rely on existing literature (Skogmalm, 2015). Skogmalm (2015) states that consultants also assists with the transition to lean manufacturing, training and assisting employees with the transition to lean and ensuring that any information gained regarding the implementation of lean manufacturing is utilized in an effective manner. The flow of knowledge within a lean manufacturing organisation is fluid and knowledge gained regarding the lean implementation can be applied in accordance with the context of any situation within a manufacturing process. Such a flow is not dependent on any given department gaining knowledge but allows for all departments and aspects involved in the manufacturing process to work together in gaining and disseminating knowledge so that it is applied effectively to all aspects that are relevant to that particular aspect of knowledge (Dumbrowski, et al., 2012).

2.11 Conclusion

This chapter focused on defining lean manufacturing and presented the history of lean manufacturing. This was followed by a discussion of the challenges and critical success factors. The Toyota production system was also reviewed as well as the principles of lean manufacturing. The presentation of different tools formed the basis of the survey instrument. The review justified that lean manufacturing has not been explored much into electronic manufacturing. Lean manufacturing has been costly to entrench in automotive manufacturing. The concluding remarks show that lean manufacturing requires involvement from everyone. Employees play a vital role in implementation and transformation. Employees are the key to the change. The next chapter will outline the research methodology and research design

CHAPTER 3

METHODOLOGY

3. 1 Introduction

This chapter focuses on the research paradigm and research design by detailing the methodology. The population is described and the sampling strategy is discussed. The data collection procedure and research instrument and data analysis technique are described. Attention is drawn to ethical aspects of the study.

3.2 Aim and Rationale

The aim of this research is to identify the possible or potential of adopting lean manufacturing principles in the electronic manufacturing industry, particularly Altech UEC. The objectives of the study are:

- To capture employees' perception of lean manufacturing and the principles that they believe have been implemented within Altech UEC;
- To establish the impact being made or lack thereof of implementing lean manufacturing at Altech UEC;
- To ascertain the challenges being faced by the implementation of lean manufacturing at Altech UEC; and
- To explore the ways in which the implementation of lean manufacturing can be improved within Altech UEC.

This study seeks to review the perceptions of employees of Altech UEC of lean manufacturing and how lean manufacturing is currently being applied by Altech UEC. The literature reviewed has provided insight into the lack of research done into lean manufacturing within an electronic manufacturing organization and the challenges faced in implementing lean manufacturing as an effective system of operation. The study allows for the perspectives of higher and middle levels of management to be obtained regarding lean manufacturing. This study aims to identify the possible or potential of adopting lean manufacturing principles in the electronic manufacturing industry, particularly to Altech UEC.

This study seeks to understand what Altech UEC employees feel is necessary to ensure that a sufficient level of quality is maintained within a manufacturing organisation and will provide insight into the understanding employees have of the various lean principles and lean concepts that are necessary for the successful implementation of lean manufacturing. By understanding the level of lean manufacturing implementation within a manufacturing organisation, this study can also determine what Altech UEC employees view as waste material and identify the kind of waste produced within the manufacturing process within the South African context. It will also provide insight into the adaptation of lean manufacturing tools and principles to the needs of the South African manufacturing industry, with a focus on the technological manufacturing industry.

3.3 Research Paradigm

A research paradigm is "the set of common beliefs and agreements shared between scientists about how problems should be understood and addressed" (Kuhn, 1962:45). Malterud (2001) states that the research paradigm can be thought of as the researcher's lens, with which he/she views the world. According to Guba (1990), research paradigms can be characterised through their:

i. ontology : what is reality?
ii. epistemology : how do you know something?
iii. methodology : how do you go about finding it out?

According to Patel (2015), the three most common paradigms are:

i. positivists, who believe that there is a single reality, which can be measured and known and therefore they are more likely to use quantitative methods to measure this reality.
ii. constructivists, who believe that there is no single reality or truth and, therefore, reality needs to be interpreted. They are more likely to use qualitative methods to get those multiple realities; and
iii. pragmatists, who believe that reality is constantly renegotiated, debated, interpreted and, therefore, the best method to use is the one that solves the problem

The ontological consideration in this study is that social entities should be considered as social constructions built up from the perceptions and actions of social actors. This study adopts a positivist epistemological position that advocates the application of the methods of natural sciences to the study of social reality, an approach that is common to studies in the Management Sciences.

3. 4 Research Design

There are two methods that can be used when planning the research design of a study; a qualitative research design and quantitative research. According to Tredoux and Durrheim (2006), a qualitative approach allows for the data collected to be analysed using non-statistical methods which make inferences about a sample based on previous research and interpretations made by the researcher and makes use of smaller sample sizes and a more personal approach in collecting data such as group discussions and face-to-face interviews (Richards, 2006). A quantitative approach analyses the data using statistics and numbers and makes statistical inferences about the population of interest based on a statistical approach to the collection of data (Tredoux and Durrheim, 2006). A quantitative study attempts to break down observable and realistic situations into a numerical format that allows for the statistical explanation of the phenomena being studied. Due to the statistical nature of the questionnaire, as it is in a Likert scale format, only a quantitative research design was required.

3. 4. 1 Quantitative Research Design

The research design of the study was constructed within a quantitative research design format, which means that the study takes a mathematical and statistical approach in how the research was carried out and how the analysis of the data will be handled (Labaree, 2009). This method was chosen for the study as quantitative research allows for the numerical representation of social phenomena. Quantifying the responses of the participants from the Likert scale format of the questionnaire allows for a minimal margin of error and misinterpretation (Tredoux and Durrheim, 2006). A quantitative study attempts to break down observable and realistic situations into a numerical format that allows for the statistical explanation of the phenomena being studied (Tredoux and Durrheim, 2006). The study takes a quantitative approach as the variables being examined can be quantified and mathematically examined.

3.5 Case Study

There are multiple definitions of a case study**.** According to Bromley (1990:302), it is a "systematic inquiry into an event or a set of related events which aims to describe and explain the phenomenon of interest." Yin (1984:23) defines a case study research method as an empirical inquiry that investigates a contemporary phenomenon within its real-life context, when the boundaries between phenomenon and context are not clearly evident and in which multiple sources of evidence are used.

Simons (2009) and Merriam (1998) state that selecting a case study for research does not imply the selection method but the methods selected depend on naturally occurring sources, such as people or observation of interactions occurring in a physical space (Stake, 1995). Firstly, there should be some rationale for case study research design. According to Yin (2003), the case study approach would be most appropriate or should be considered when the focus is on answering “how” and “why” questions. Yin (2003) also states that there are three approaches to case study research, as described below:

i. explanatory: where the focus is on seeking to find answers to questions around presumed causal links in real-life phenomena;
ii. exploratory: to explore situations where there is no clear, single set of outcomes for the phenomena; and
iii. descriptive: used to describe a phenomenon and the real-life context in which it occurred.

The approach selected for a particular study should be aligned to and determined by the research questions posed (Yin 2014). For this study, the researcher has employed the descriptive case study research.

3.6 Population and Sampling

3.6.1 Population

The population makes reference to a group of individuals in which the study is interested in examining (Welman, et al., 2005). This study is interested in the population of shop floor and management employees at the manufacturing organisation Altech UEC, which consisted of 250 individuals as recorded in the HR database. This population consists of employees from the different shifts in the different departments at Altech UEC.

3. 6. 2 Sampling

The term sampling is used to refer to a group of individuals that has been extracted from a larger pool of individuals who are the population of interest for any given study (Tredoux and Durrheim, 2009). To ensure that the sample is a fair representation of the target population, there are several methods of sampling that can be used. The selection of a sample is based on the chance of an individual being selected for the study at hand and ensuring that this is in no way influenced by the researcher or extraneous variables. Due to the difficulty that is represented by methods of probability sampling that rely on the random selection of participants, alternatives can be used to ensure that the sample chosen is done so in a practical and methodological manner, and in no way compromises the data that are being collected.

There are two methods of sampling; probability and non-probability sampling. Probability sampling is any method of sampling that chooses the individuals of the sample from the population of interest at random and there is no specific pattern or design in the choice of participants who make up the sample of the study (Trochim, 2006). Non-probability sampling is a sample that is chosen by the researcher based on a set of traits or characteristics that are of interest to the researcher (Steinke, 2004).

This research study will implement a probability method of sampling which ensures an accurate representation of the target population. The method used is known as stratified random sampling in which the population of interest falls into groups without any kind of interference or adjustment on the part of the researcher, and thereby ensures that the use of chance in the selection of participants is carefully thought out and planned to ensure that the groups present within the target population are each represented fairly. The groups within this study are categorized in accordance with the work and department in which each employee participates. The employees being sampled are based within the manufacturing plant at Altech UEC and have been chosen from the manufacturing department within the factory to ensure that the population of interest has been accurately represented.

The number of employees on site was taken from the human resources database. The current population size, including operators and junior to middle management is approximately 250 employees. A sample of 152 employees was chosen from this target population of 250, which was a large representation of the population of interest and ensured that the data collected was a fair measurement of the demographics and described the nature of the population being sampled. According to Sekaran and Bougie (2010), for a population of 250, a sample size of 152 is considered to be satisfactory.

3. 7 Research Instrument

3.7.1 Survey Instruments

According to Zikmund and Babin (2010) a survey is a research technique in which responses are collected through a structured instrument from a sample in some form or the behaviour of respondents is observed and described in some way. Saunders, Lewis and Thornhill (2007) state that surveys are linked to deductive logic and are a regular method of collecting data in management research by employing a questionnaire that collects data from a sample. Zikmund (2003) further states that surveys have become accepted as a scientific and accurate way of collecting data to quantify gathered information. According to Hague (2002), surveys are an efficient way of gathering information about the population and are inexpensive. Monette, Sullivan and Dejong (2011) regard a questionnaire as a way to collect data in survey research that contains recorded questions that people respond to directly on the questionnaire form.

According to Wilkinson and Birmingham (2003:39), a questionnaire has advantages as well as disadvantages. These are listed below:

The table below compares the advantages and disadvantages of a questionnaire.

Table 3.1: Questionnaire advantages and disadvantages

Advantages	Disadvantages
It is familiar to users and allows them to complete the questionnaire at their own convenience, while allowing some time to think about their answers.	Questionnaires often provide low response (return rates), time-consuming follow-up and data entry.
Questionnaires facilitate the collection of vast amounts of data with minimal effort.	Ease of production and distribution can result in the collection of far more data that can be effectively used.
The availability of a number of participants in one place makes possible economy of time and expense and provides a high proportion of useable responses.	Questionnaires are distributed all the time, competing for participant’s time.
As research instruments, questionnaires can be used time and time again to measure differences between groups of people. They are thus reliable data gathering tools.	Lack of adequate time to complete the instrument may result in the return of superficial data.
The person administering the instrument has the opportunity to establish rapport, explain the purpose of the study and elaborate on the	Lack of personal contact (if the questionnaire is mailed) may mean that response rates suffer, necessitating the

meaning of items that may not be clear.	expense of follow-up letters, telephone calls and other means of chasing the participant.

3. 7. 2 Adaptation of Questionnaire

The questionnaire used by the researcher in this study has been adapted from previous research by Karlsson and Ahlstrom (1996), and includes nine lean manufacturing principles. This was further developed by Rathilall (2011) and was used in an automotive industry where the aim of the research was to analyse an organisation's response to lean manufacturing principles on process and quality improvement at a local automotive manufacturing organisation based in Durban. The researcher has included the nine lean manufacturing principles, as developed by Rathilall (2011) and has also added principles from a questionnaire developed by Marin-Garcia and Carneiro (2010). The rationale for using a previously developed questionnaire was that the previous study was conducted in an automotive industry where lean manufacturing principles are well entrenched. The reliability Cronbach alphas from the above previous studies are listed below:

Table 3.2: Cronbach alphas from Previous Study

No.	Item	Cronbach alpha
1	Elimination of Waste	0.844
2	Continuous Improvement	0.845
3	Zero Defects	0.832
4	Just in time	0.979
5	Multifunctional teams	0.593
6	Decentralised responsibilities	0.745
7	Integrated functions	0.607
8	Vertical information systems	0.831
9	Pull Instead of Push	0.773
10	Visual Management	0.813
11	SMED	0.924
12	Supplier Relations	0.831
13	Customer Relations	0.759
14	Knowledge Management	0.921

Cronbach alphas values from studies conducted by Rathilall (2011) and Marin-Garcia and Carneiro (2010)

All questions covered were adapted for an operator level of understanding to accommodate the level of education of any given participant. The questions chosen ensured that the topics of interest of the study were covered comprehensively and the list of questions under each topic was not long or redundant in nature. Each section had, at least, four questions below the topic of interest and the questions were not phrased in a manner that could be seen as ambiguous and be misconstrued by participants. The items in the questionnaire ensured that all information gathered would be important to all areas of lean manufacturing and have future applicability to other studies that are similar in nature to the study that was carried out.

3.7.3 Description of Questionnaire

The questionnaire had 3 sections; the first section requires participants to provide details regarding the department in which they were employed. The departments were logistics, stores, quality control, surface mount department (SMD), enclosures, final integration, despatch, process engineering, test engineering and material planning.

The second section of the questionnaire required participants to indicate the position of employment that was held by the participant. The positions were operator, section manager, engineer, inspector, administration, section leader/supervisor and technician.

The final section provided questions in relation to study and the research questions. There were fourteen sections covered in total and each section had between 4 to 6 questions pertaining to a particular section. The sections were elimination of waste, continuous improvement, zero defects, just-in-time, multifunctional teams, decentralized responsibilities, integrated functions, vertical information systems, pull instead of push, visual management, SMED, supplier relations, customer relations and knowledge management.

A Likert scale provides a rating format with a scale that normally consists of 5 to 7 items that can be used to rate the subject or item which is being analysed by the questionnaire being answered (Allen and Seaman, 2007). The questionnaires were structured into a Likert scale format in which 5 options were provided to participants (Strongly disagree, disagree, not sure, agree, strongly agree). This data provided by the questionnaire was ordinal in nature, which meant that the rating and ranking of the responses was possible but there was no definable measure of distance between the responses that were provided (Allen and Seaman, 2007).

3.7.4 Administration of the Questionnaire

The questionnaire was administered to employees to gain perspective on how the employee population views the level of lean implementation within the manufacturing organisation. By doing so, this study effectively gauged the understanding employees have of lean manufacturing and gained insight into the degree to which employees believe lean manufacturing is used as a means of business and as an operating system at their manufacturing organisation. No participant turned down the opportunity to participate in the research, and all information was collected from the sample was by the researcher, and not a third party, to ensure that the information of participants was not compromised in any way.

3.7.5 Piloting the Questionnaire

The questionnaire was tested extensively on a control group of 10 employees (who were not part of the main study) before administering the questionnaire to participants. This was done so that all concepts and topics discussed within the questionnaire were comprehended effectively and interpreted correctly by respondents. Therefore, the questionnaire was appropriately adapted for use within the context of the environment. There were no items that were misinterpreted by participants that could skew the results obtained from the study as a whole. Participants were selected from the human resources data base at Altech UEC.

3.8 Data Analysis

Several tests were carried out to test and analyse the data being collected. Descriptive statistics were used to describe the dataset in its entirety and is an effective measure in attempting to summarize the data being collected. It explores all technical and general aspects of the data, such as the demographics of the sample, and provides a comprehensive view of the dispersion of the data and the position of the mean within the data. A univariate analysis in the computer statistics program SPSS version 24.0 was used. A univariate analysis looks at one single variate at a given time, SPSS allows for the analysis and summation of each variable required for a comprehensive overview of all descriptive statistics required for the study. SPSS allows for the central frequency to be determined as well as the mean and standard deviation of the data set. Details covered under the topic of descriptive statistics were, gender, race, age, department of employment, position, standard deviation, mean and central frequency.

Inferential statistics allows one to make predictions or assumptions on a particular population based on results that were obtained from testing a sample that was drawn from the population of interest (Tredoux and Durrheim, 2006). This allows one to determine whether the null hypothesis is rejected and accept the hypothesis to be true. An Analysis of Variance (ANOVA) was carried out to allow for the division of variation in a set of observations into distinct components (Tredoux and Durrheim, 2006).

To determine the correlation, between two or more variables, Spearman's correlation was used. Spearman's correlation is used to determine the relationship between 2 variables that have a linear similarity (Frederick and Larry, 2012).

Factor analysis, on the other hand, is a statistical technique whose main goal is data reduction. A typical use of factor analysis is in survey research, where a researcher wishes to represent a number of questions with a small number of hypothetical factors. For example, as part of a national survey on political opinions, participants may answer three separate questions regarding environmental policy, reflecting issues at the local, state and national levels. Each question, by itself, would be an inadequate measure of attitude towards environmental policy, but, together, they may provide a better measure of the attitude. Factor analysis can be used to establish whether the three measures do, in fact, measure the same thing. If so, they can then be combined to create a new variable, a factor score variable that contains a score for each respondent on the factor. Factor techniques are applicable to a variety of situations. One need not believe that factors actually exist in order to perform a factor analysis, but, in practice, the factors are usually interpreted, given names, and spoken of as real things (Creswell, 2005).

3.9 Reliability

Reliability of a measure is an indication of the stability and consistency with which the instrument measures the concept and helps to assess the "goodness" of a measure (Sekaran and Bougie, 2010). This study used Cronbach's alpha as a base measurement from which reliability is obtained within the study. According to Santos (1999:3), "Cronbach's alpha determines the internal consistency or average correlation of items in a survey instrument to gauge its reliability".

3.10 Validity

A study can be considered valid if it is able to successfully measure and quantify what it has set out to prove or disprove (Tredoux and Durrheim, 2006). For a study to be valid, it needs to have internal and external validity. Internal validity can be defined as a study's capability to effectively measure the social phenomena that are of interest to the study and whether they are the result of the effects of the independent variable and not some other factor (McLeod, 2013). McLeod (2013) also states that external validity is the extent to which outcomes of the research can be generalised to the population. According to Welman, Kruger and Mitchell (2005), construct validity is to determine if an instrument measures what it is supposed to measure. This study employed internal validity and construct validity from two previously derived questionnaires that was developed by Rathilall (2011) and by Marin-Garcia and Carneiro (2010).

3.11 Ethical Considerations

In accordance to the guidelines offered by Emmanuel, Wendler and Grady (2000) this study took the following principles into consideration to ensure that the wellbeing and integrity of participants was not compromised in any way;

i. Collaborative partnership ensures that the research done has taken the views of the target population regarding the topic of interest into consideration before going forth with implementing the study. This ensures that the topic being researched and analysed is within the interest of the population of interest. This study took the interests of the manufacturer into consideration by looking at the level of lean manufacturing implementation within the environment in which the study took place. The study involved participants by gathering their collective opinion on whether lean manufacturing would be an effective method for the electronics manufacturing industry and gathered their opinion on the effectiveness of the questionnaire after it was administered and collected upon completion by the researcher;

ii. The study also took into account the social value that if offered to its target population. Social value refers to whether the research being conducted impacts upon the community in a positive manner and provides information to the target population on which the study was based. The study being conducted does benefit the community of interest, that is all employees involved in the electronics industry, as it should it determine that lean manufacturing is a viable method of manufacturing for the electronics manufacturing industry, it can then be implemented into electronics manufacturing companies thereby improving the work ethics and methods being used by the employees working within the various value streams present within the factory;

iii. The fair selection of participants was also taken into account to ensure that each value stream was equally represented to ensure that the research done into the effectiveness of lean manufacturing within an electronics manufacturing organisation would benefit all value streams and improve the working lives of all employees involved and by ensuring that all participants were fairly selected, it ensures that there is a rich set of data that has been supplicated by a varied sample group;

iv. The next principle that needed to be considered was whether the benefits that the study offered outweighed the risks it presented to participants on a fairly large ratio. The probability of harm occurring had to be taken into account as well as the severity of the harm should any harm be incurred by any of the participants. To ensure that this was not the case, there were safe guards and contingencies put into place should the participants feel harassed or uncomfortable answering any of the items present on the questionnaire. Participants were allowed to leave should they have felt uncomfortable and the contact details of all parties involved were provided to participants so that they knew who to contact should they have any concerns. An independent ethics board reviewed the proposal of the study, the study was found to be ethically competent and safe to be administered to the target population before the collection of data was carried out, the study proved to offer minimal harm to participants and deemed as appropriate by the external ethical review board;

v. Informed consent ensures that participants have been provided with all relevant information pertaining to the study before they are allowed to answer the questionnaire. The researcher ensured that participants were provided with a clear and factual description of the information pertaining to the study and ensured that participants were made adequately aware of the benefits and risks that the study presented. The study did not require participants to disclose any personal information and ensured that the identity of the participant was protected through anonymity, all participation was done so on a voluntary basis and the researcher ensured that all consent was freely given and all participants possessed the necessary mental capacity to answer the questionnaire that they were presented with; and

vi. The final principle ensures that a level of respect for the participants is maintained for the duration of the data collection and is maintained once the study has been completed, this is done by ensuring that participants are aware of their right to withdraw from the study at any given stage of data collection and providing participants with any new insight that has been gained during research that pertains to the questionnaire that they were required to answer. The mental and physical wellbeing of participants was also kept in check throughout the study and all information gathered from participants was done so in a private and confidential manner.

3.12 Conclusion

This chapter provided a categorical explanation of the rationale and method used to go about conducting the study and first explained the aims and rationale of the study after which the quantitative research design used by the study was discussed. The population was then reviewed and sample frame of the study as well as all factors associated with the administration of the questionnaire. The methodology then looked at the ethical considerations taken into account for the study and discussed the method being used in data analysis. The methodology then looked at the reliability of the study and how this will be determined. The next chapter is data analysis which will provide results that will answer the research questions of the study and an explanation for why these results were achieved.

CHAPTER 4

STATEMENT OF FINDINGS, INTERPRETATION AND DISCUSSION OF THE PRIMARY DATA

4.1 Introduction

This chapter presents the results and discusses the findings obtained from the questionnaire in this study. The questionnaire was the primary tool that was used to collect data and was distributed to employees at Altech UEC. The data collected from the responses were analysed with SPSS version 24.0. The results presented the descriptive statistics in the form of graphs, cross tabulations and other figures for the quantitative data. Inferential techniques include the use of correlations and chi square test values; which are interpreted using the p-values.

4.2 The Sample

Questionnaires were distributed to shop floor operators and junior to middle management by hand delivery. For shop floor operators, the questionnaire was distributed over two shifts with a group meeting explaining the aim of the study. The discussion also included employees' enquiries. The completed questionnaire was handed back to the shift supervisor within four days. The shift supervisor then handed all completed questionnaires to the researcher at the end of the shift. In total, 152 questionnaires were despatched and 136 were returned, which resulted in an 89.5% response rate.

4.3 The Research Instrument

The research instrument consisted of 79 items, with a level of measurement at a nominal or an ordinal level. According to Welman et al. (2005), a nominal level is where individuals are placed in different categories and are only distinguished in terms of attribute being measured. While the ordinal level of measurement reflects differences among individuals in variables being measured.

The questionnaire was divided into 15 questions which measured various themes. The themes that were measured were biographical data and 14 lean manufacturing tools.

4.4 Biographical Data

This section summarises the biographical characteristics of the respondents.

Table 4.1below indicates the department of the respondents.

Table 4.1: Respondents by department

Department	Frequency	Percent
SMD /AI / Testing	46	33.8
Final Integration	46	33.8
Enclosures	12	8.8
Stores	7	5.1
Quality Control	7	5.1
Process Engineering	7	5.1
Logistics	6	4.4
Despatch	2	1.5
Test Engineering	2	1.5
Material Planning	1	0.7
Total	**136**	**100.0**

Below is a brief explanation of some of the departments listed above:

- SMD / AI/ Testing: SMD (Surface Mount department) is where operators load components into the machine and the machines place these components onto on printed circuit board (PCB). AI (manual insertion) is where operators manually insert components onto printed circuit boards that machines cannot place. Testing is where the completed printed circuit boards are tested for functionality. These three departments are normally referred to as electronic assembly.
- Final Integration is a department where the products from different areas are integrated to form the final product.
- Enclosures refers to a department that moulds plastic components. In other words the plastic parts are the enclosures for the end product.

From the above table, it can be deduced that the highest SMD/AI/Testing and Final Integration departments since these departments had the highest number of employees.

The positions held by respondents are reflected in table 4.2 below

Table 4.2: Respondents' position

Position	Frequency	Percent
Operator	104	76.5
Inspector	7	5.1
Administration	7	5.1
Technician	7	5.1
Section leader / Supervisor	6	4.4
Engineer	3	2.2
Section Manager	2	1.5
Total	**136**	**100.0**

In total, 76.5% respondents were from operators. This was to be expected as the population was mainly made up of operators who are from the departments, SMD/Ai/Testing (33.8%), Final Integration (33.8%) and Enclosures (8.8%).

4.5 Sectional Analysis

4.5.1 Question 1: Elimination of Waste

Karlsson and Ahlstrom (1996) define waste as any aspect in an organisation and within the manufacturing process that does not add value to the product that is being produced.

Table 4.3 depicts the results for elimination of waste responses.

Table 4.3: Responses to section on elimination of waste

		Disagree		Not sure		Agree		Chi-Square
Section	Question	Response Count	Row N %	Response Count	Row N %	Response Count	Row N %	p-value
S1.1	Work in progress Inventory is kept to a minimum.	97	71.3%	8	5.9%	31	22.8%	0.000
S1.2	All purchasing are via MRP or sales order	1	0.7%	12	8.8%	123	90.4%	0.000
S1.3	Lot sizes are continuously monitored and reduced to keep inventory down.	99	72.8%	13	9.6%	24	17.6%	0.000
S1.4	The number of times parts are transported within the different manufacturing cells are kept to a minimum.	93	68.4%	7	5.1%	36	26.5%	0.000
S1.5	The shortest distances are maintained to transport parts within the different manufacturing cells.	90	66.2%	5	3.7%	41	30.1%	0.000
S1.6	Manufacturing cycle times are kept to a minimum. Employees do not spend excessive time waiting for a cycle to be completed.	8	5.9%	6	4.4%	122	89.7%	0.000
S1.7	All tools and processes are capable of producing quality goods.	7	5.1%	2	1.5%	127	93.4%	0.000
S1.8	Defects resulting in scrap and rework are constantly monitored.	68	50.0%	6	4.4%	62	45.6%	0.000

Figure 4.1 below graphs the results for the elimination of waste responses.

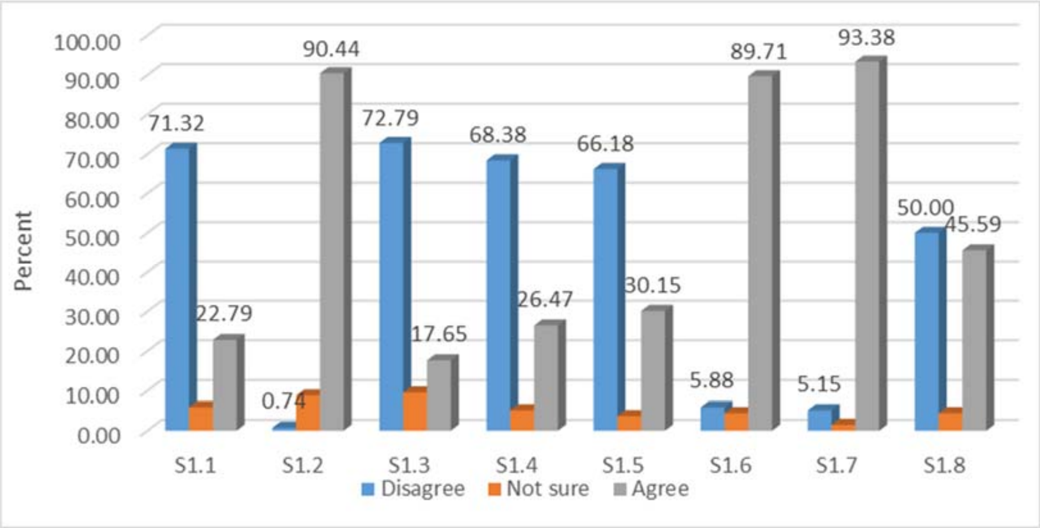

Figure 4.1: Responses to section on elimination of waste

The following patterns are observed:

i. Three statements show (significantly) higher levels of agreement; and five statements indicate higher levels of disagreement.

The significance of the differences is shown in the table 4.3.

A chi-square test was conducted to determine whether the scoring pattern for each statement was significantly different in comparison with other options in the same question. In terms of the null hypothesis, around the same number of respondents scored across each option per question. On the contrary, the alternate hypothesis states that there is a significant difference between the levels of agreement and disagreement. The aforementioned results are illustrated in table 4.3. The highlighted significant values (p-values) are less than 0.05, which implies that the distributions were different, i.e., the differences in the manner in which respondents scored (agree, not sure, disagree) were significant.

4.5.2 Question 2: Continuous Improvement

This section deals with the continuous improvement of lean manufacturing practices.

Continuous improvement can be seen as vital to the success of lean manufacturing within an organisation as this tool of lean manufacturing emphasizes the involvement of all employees involved in the process of manufacturing and ensures that all employees work together towards improving the manufacturing process, which is continuously monitored to identify further areas of improvement (Karlsson and Ahlstrom, 1996).

Table 4.4 depicts the results for continuous improvement responses.

Table 4.4: Responses to section on continuous improvement

		Disagree		Not sure		Agree		Chi-Square
Section	Questions	Response Count	Row N %	Response Count	Row N %	Response Count	Row N %	p-value
S2.1	All employees are involved in continuous improvement activities.	112	82.4%	2	1.5%	22	16.2%	0.000
S2.2	Since employees have first-hand knowledge of their processes their views are never underestimated by management.	109	80.1%	3	2.2%	24	17.6%	0.000
S2.3	Appropriate feedback is consistently provided on continuous improvement initiatives.	108	79.4%	7	5.1%	21	15.4%	0.000
S2.4	All employees have been trained on continuous improvement.	93	68.4%	26	19.1%	17	12.5%	0.000
S2.5	The number of suggestions per employee is monitored.	115	84.6%	7	5.1%	14	10.3%	0.000
S2.6	Operators gather in groups to come up with suggestions on possible improvements.	112	82.4%	12	8.8%	12	8.8%	0.000
S2.7	The PDCA methodology is consistently used to address problems and close them off consistently.	12	8.8%	20	14.7%	104	76.5%	0.000
S2.8	The 5S methodology is used to maintain a clean and organised working environment.	4	2.9%	6	4.4%	126	92.6%	0.000

Figure 4.2 below graphs the results for the continuous improvement responses.

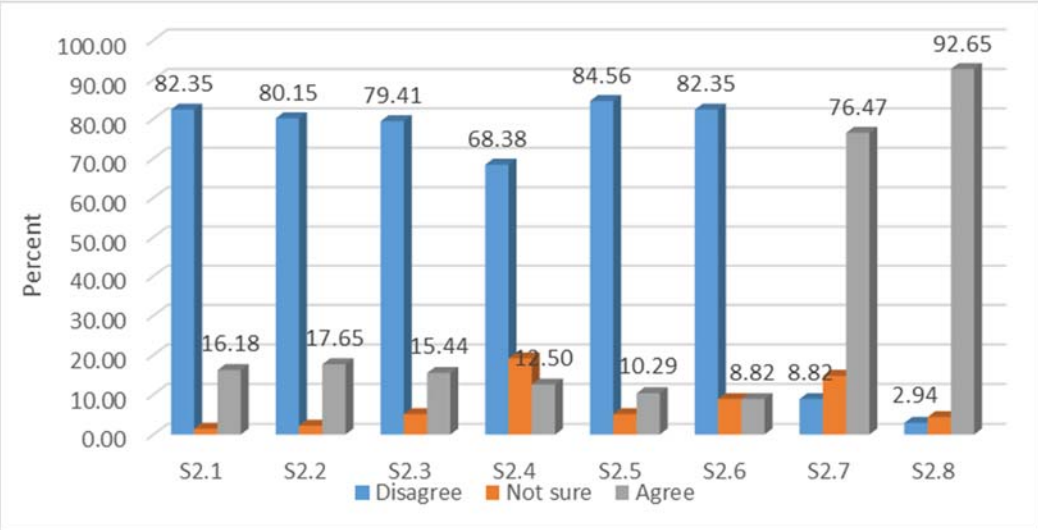

Figure 4.2: Responses to the section on continuous improvement

The following patterns were observed within the data:

i. there were six questions posed to participants that had a significantly high level of disagreement with the question statement; and
ii. there were two questions answered by participants that displayed significantly high levels of agreement with the question statement.

The significance of the differences is shown and tested in the table 4.4.
The factor analysis carried out (appendix 1) shows that the statements displaying high levels of disagreement form a theme in which the lack of employee participation in the continuous improvement in lean manufacturing practices is evident. The theme formed by the two statements that had significantly high levels of agreement showed that all processes involved in the maintenance of work stations were efficient.

A chi-square test was conducted to determine whether the scoring pattern for each statement was significantly different in comparison with other options in the same question. In terms of the null hypothesis, around the same number of respondents scored across each option per question. On the contrary, the alternate hypothesis states that there is a significant difference between the levels of agreement and disagreement. The aforementioned results are illustrated in table 4.4. The highlighted significant values (p-values) are less than 0.05, which implies that the distributions were different, i.e., the differences in the manner in which respondents scored (agree, not sure, disagree) were significant.

4.5.3 Question 3: Zero Defects

This section measures zero defects within the lean manufacturing process.
Karlsson and Ahlstrom (1996) state that zero defects are a way of thinking and doing production tasks right the first time without manufacturing defects. This philosophy increases the organisations profits by eliminating the cost of failure and increasing revenues through increased customer satisfaction.

Table 4.5 depicts the results for zero defects' responses.

Table 4.5: Responses to section on zero defects

		Disagree		Not sure		Agree		Chi-Square
Section	Questions	Response Count	Row N %	Response Count	Row N %	Response Count	Row N %	p-value
S3.1	Operators are responsible to identify defective parts at the source of the operation.	8	5.9%	4	2.9%	124	91.2%	0.000
S3.2	Operators are permitted to stop the line in the event that defective parts are noticed.	105	77.2%	4	2.9%	27	19.9%	0.000
S3.4	Defective parts are reworked at the workstation where the defect was identified.	103	75.7%	4	2.9%	29	21.3%	0.000
S3.5	Measuring and inspection is carried out at the end of every process and after the product is fully assembled.	9	6.6%	7	5.1%	120	88.2%	0.000
S3.6	Autonomous defect control such as Poke-Yoke devices are used as a majority source of inspection methodology.	18	13.2%	26	19.1%	92	67.6%	0.000
S3.7	Operators are responsible for quality.	5	3.7%	5	3.7%	126	92.6%	0.000

Figure 4.7 below graphs the results for zero defect responses.

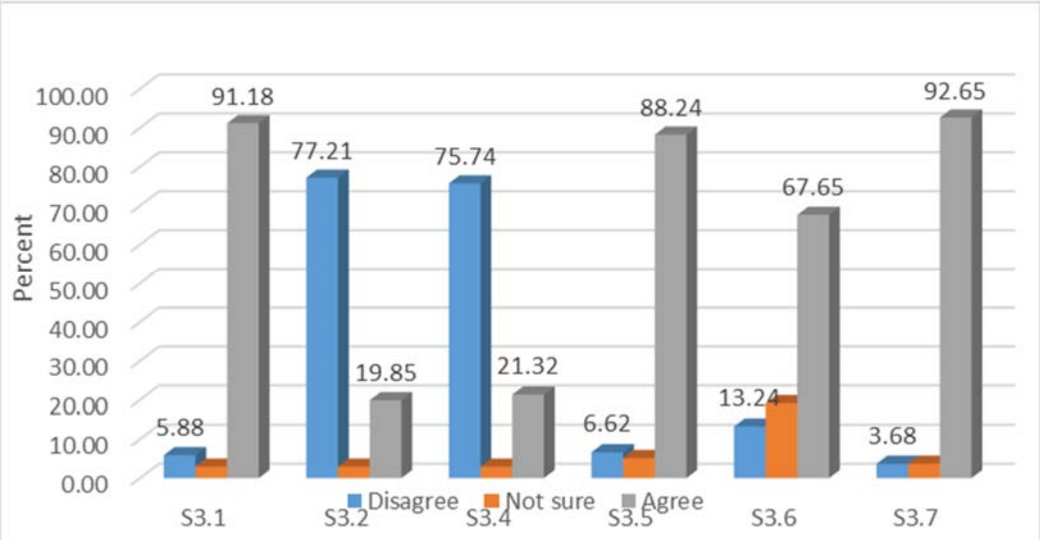

Figure 4.3: Responses to section on zero defects

The following patterns were observed within the data:

i. four of the questions display significantly higher levels of agreement with the question statement; and

ii. two of the questions showed significant levels of disagreement with the statement question.

The significance of the differences is tested and shown in the table 4.5.

The analysis carried out shows that a sub-theme emerges from the statements that had significantly higher levels of agreement. This theme demonstrates that there is a level of inspection and correction of parts that are seen as defective. The statements that had a significantly high level of disagreement from participants demonstrate that there is little done to control the removal of parts that have been identified as defective.

A chi-square test was conducted to determine whether the scoring pattern for each statement was significantly different in comparison with other options in the same question. In terms of the null hypothesis, around the same number of respondents scored across each option per question. On the contrary, the alternate hypothesis states that there is a significant difference between the levels of agreement and disagreement. The aforementioned results are illustrated in table 4.5. The highlighted significant values (p-values) are less than 0.05, which implies that the distributions were different, i.e., the differences in the manner in which respondents scored (agree, not sure, disagree) were significant.

4.5.4 Question 4: Just-In-Time

This section deals with the just-in-time processes of lean manufacturing.

Kim (1985) states that just-in-time is a system that can be defined as the precise and effective time management of when a product is manufactured, in the necessary quantities in the allotted time of manufacturing and is delivered and distributed at the appropriate time.

Table 4.6: depicts the results for just-in-time.

Table 4.6: Responses to section on just-in-time

		Disagree		Not sure		Agree		Chi-Square
Section	Questions	Response Count	Row N %	Response Count	Row N %	Response Count	Row N %	p-value
S4.1	Each process is provided with the required part, in the correct quantity at the exact point in time.	94	69.1%	6	4.4%	36	26.5%	0.000
S4.2	Production lot sizes, buffer sizes and order lead time are continuously reduced to ensure just-in-time production.	106	77.9%	5	3.7%	25	18.4%	0.000
S4.3	Suppliers deliver at the time of consumption.	115	84.6%	11	8.1%	10	7.4%	0.000
S4.4	All processes use a pull system rather than push.	102	75.0%	16	11.8%	18	13.2%	0.000
S4.5	Inventory levels between work centres are kept to minimum.	102	75.0%	10	7.4%	24	17.6%	0.000

Figure 4.4 below graphs the results for the just-in-time responses.

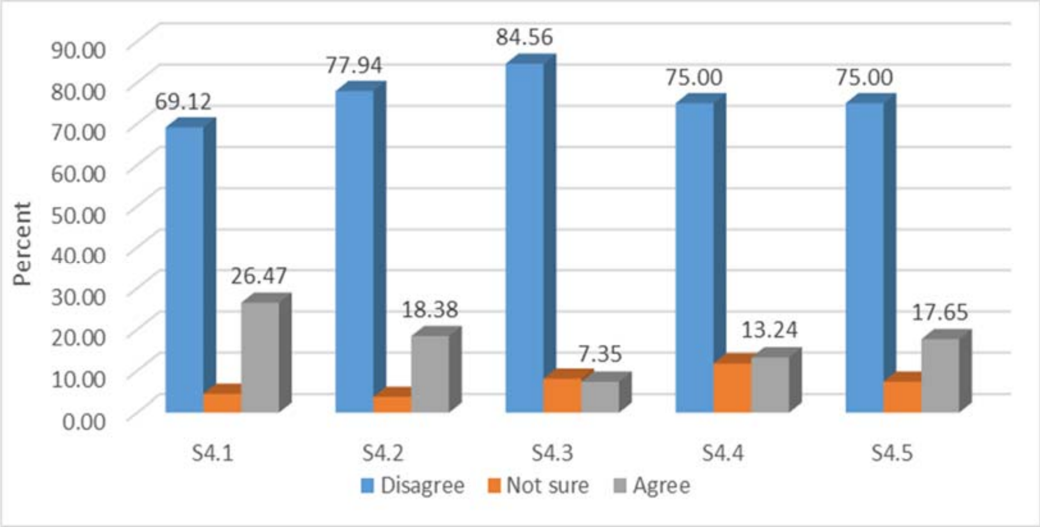

Figure 4.4: Responses to section on just-in-time

The following pattern was observed:

i. All the statements displayed significant levels of disagreement.

The significance of this pattern is shown and tested in table 4.6.

The lack of agreement with any of the statements shows that there is a total lack of improving the time taken to carry out tasks and reducing the total amount of time required to complete the manufacturing process. This finding shows that the manufacturing process currently in use is not efficient or quick enough to allow for the reduction of time in the individual processes involved with the manufacturing process.

A chi-square test was conducted to determine whether the scoring pattern for each statement was significantly different in comparison with other options in the same question. In terms of the null hypothesis, around the same number of respondents scored across each option per question. On the contrary, the alternate hypothesis states that there is a significant difference between the levels of agreement and disagreement. The aforementioned results are illustrated in table 4.6. The highlighted significant values (p-values) are less than 0.05, which implies that the distributions were different, i.e., the differences in the manner in which respondents scored (agree, not sure, disagree) were significant.

4.5.5 Question 5: Multifunctional Teams

This question is a discussion of the implementation of multifunctional teams within the manufacturing process.

According to Vienazindiene and Ciarniene (2013), multifunctional teams can be defined as a group of employees who are capable of performing a large number of different functions as a result of extensive training and education to ensure that lean manufacturing runs efficiently and is successfully applied within the context of the organisation.

Table 4.7 depicts the results for multifunctional teams' responses.

Table 4.7: Responses to section on multifunctional teams

		Disagree		Not sure		Agree		Chi-Square
Section	Questions	Response Count	Row N %	Response Count	Row N %	Response Count	Row N %	p-value
S5.1	Multifunctional teams exist within the organisation and are arranged at the different manufacturing processes.	102	75.0%	6	4.4%	28	20.6%	0.000
S5.2	The number of employees working in multifunctional teams should increase.	34	25.0%	11	8.1%	91	66.9%	0.000
S5.3	Employees within multifunctional teams perform many different tasks in the product flow.	98	72.1%	6	4.4%	32	23.5%	0.000
S5.4	Tasks are rotated amongst multifunctional team members.	104	76.5%	10	7.4%	22	16.2%	0.000
S5.5	There is no reliance or dependence on single employees performing a specific task.	91	66.9%	9	6.6%	36	26.5%	0.000
S5.6	Employees are trained in performing various tasks in the production process.	99	72.8%	6	4.4%	31	22.8%	0.000
S5.7	Teamwork promotes trust, support, respect and collaboration.	15	11.0%	4	2.9%	117	86.0%	0.000

Figure 4.5 below graphs the results for multifunctional teams' responses.

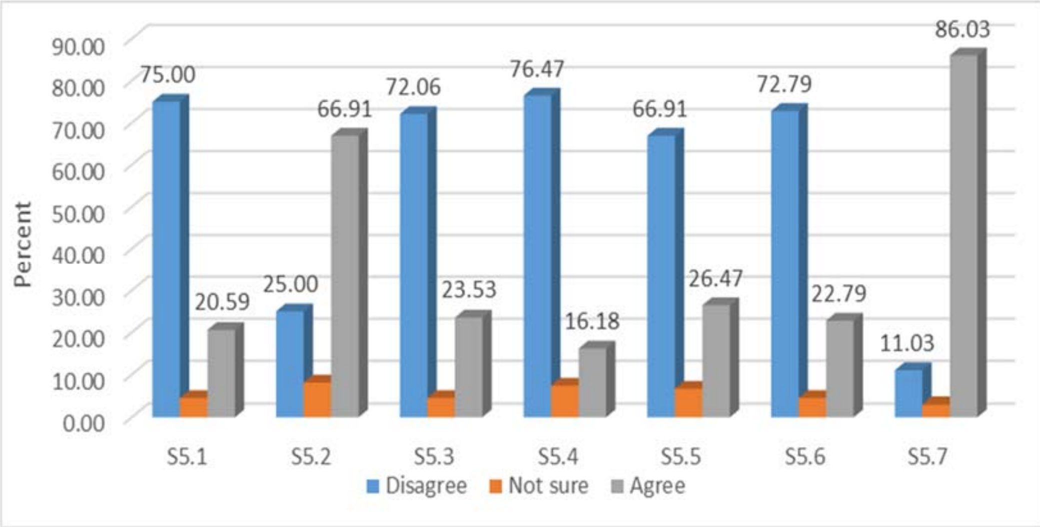

Figure 4.5: Responses to section on multifunctional teams

The following patterns were observed within the data:

i. five of the questions in this section had a significantly high level of disagreement with the statement made in the question; and

ii. two questions had a significantly high level of agreement with the statement made within the question

The significance of these differences is illustrated within table 4.7.

The patterns within the data regarding the significant levels of disagreement within five of the statements of this section indicate that there is a lack of multifunctional teams within the organisation, thereby limiting the capacity of workers and their ability to perform several different tasks within the manufacturing process. The statements that had high levels of agreement indicate a need for more teamwork within the workplace to streamline the manufacturing process.

A chi-square test was conducted to determine whether the scoring pattern for each statement was significantly different in comparison with other options in the same question. In terms of the null hypothesis, around the same number of respondents scored across each option per question. On the contrary, the alternate hypothesis states that there is a significant difference between the levels of agreement and disagreement. The aforementioned results are illustrated in table 4.7. The highlighted significant values (p-values) are less than 0.05, which implies

that the distributions were different, i.e., the differences in the manner in which respondents scored (agree, not sure, disagree) were significant.

4.5.6 Question 6: Decentralized Responsibilities

This section deals with the decentralisation of responsibilities within the lean manufacturing process.

Scott et al. (2001) defined decentralised responsibilities as the process of transferring and assigning decision-making authority to lower level employees in an organisation hierarchy.

Table 4.8 depicts the results for decentralised responsibilities.

Table 4.8: Responses to section on decentralised responsibilities

		Disagree		Not sure		Agree		Chi-Square
Section	Questions	Response Count	Row N %	Response Count	Row N %	Response Count	Row N %	p-value
S6.1	Operators are responsible for planning, maintenance, inspection and quality to prevent the disruption of product flow.	122	89.7%	4	2.9%	10	7.4%	0.000
S6.2	Supervisory tasks are performed by multifunctional teams through rotating team leadership among employees especially trained for that specific task.	108	79.4%	7	5.1%	21	15.4%	0.000
S6.3	The number of hierarchical levels in the organisation is kept to a minimum.	112	82.4%	9	6.6%	15	11.0%	0.000
S6.4	Operators are encouraged to make decisions concerning production, quality and maintenance.	108	79.4%	4	2.9%	24	17.6%	0.000
S6.5	Employees have real influence and power when they participate in decision making instead of serving as consultants.	103	75.7%	6	4.4%	27	19.9%	0.000

Figure 4.6 below graphs the results for decentralised responsibilities' responses.

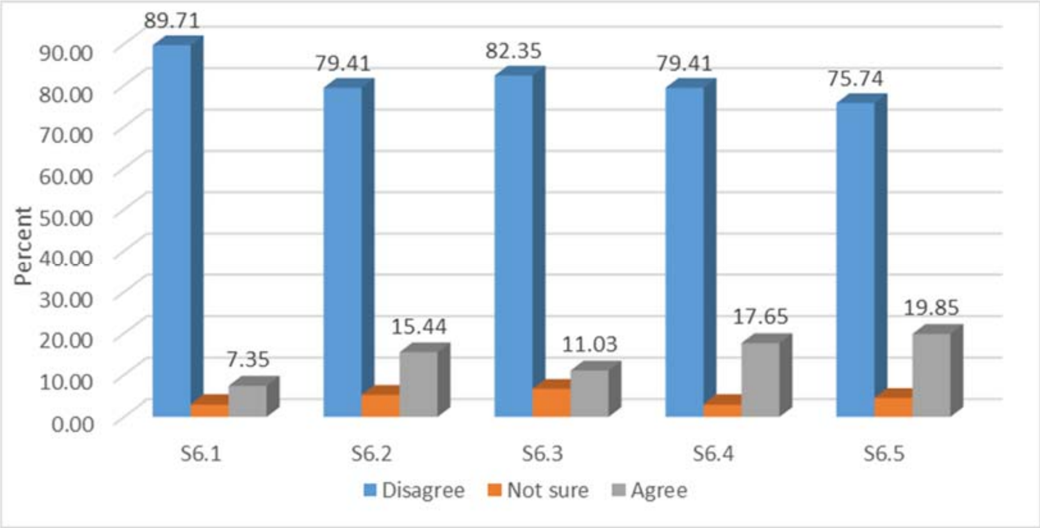

Figure 4.6: Responses to section on decentralised responsibilities

The following patterns were observed:

i. All statements within this section of the questionnaire displayed significant levels of disagreement with each question.

The significance of the differences is tested and shown in the table 4.8.

The total disagreement with the statement at hand indicates that all major aspects within the manufacturing are not controlled and overseen by a multifunctional team. However, it is controlled by one individual acting in a supervisory role or a member of management and employees involved in the actual manufacturing process have very little or no say when it comes to decisions regarding aspects of the organisation that they are employed by.

A chi-square test was conducted to determine whether the scoring pattern for each statement was significantly different in comparison with other options in the same question. In terms of the null hypothesis, around the same number of respondents scored across each option per question. On the contrary, the alternate hypothesis states that there is a significant difference between the levels of agreement and disagreement. The aforementioned results are illustrated in table 4.8. The highlighted significant values (p-values) are less than 0.05, which implies that the distributions were different, i.e., the differences in the manner in which respondents scored (agree, not sure, disagree) were significant.

4.5.7 Question 7: Integrated Functions

The following section discusses the integrated functions that are carried out by multifunctional teams.

Integrated functions is also a component related to multifunctional teams. According to Karlsson and Ahlstrom (1996:37) can be defined as "the integration of different functions into the teams", which means that any tasks and activities, previously performed by designated groups of employees that indirectly affected the manufacturing process, now became the responsibility of the multifunctional team who handled the processes.

Table 4.9 depicts the results for integrated functions responses.

Table 4.9: Responses to section on integrated functions

		Disagree		Not sure		Agree		Chi-Square
Section	Questions	Response Count	Row N %	Response Count	Row N %	Response Count	Row N %	p-value
S7.1	Indirect tasks such as materials handling, planning, maintenance, and quality control, are performed by multifunctional teams.	103	75.7%	3	2.2%	30	22.1%	0.000
S7.2	The number of tasks performed by multifunctional teams should increase, thus reducing the ratio of indirect employees to direct employees.	61	44.9%	10	7.4%	65	47.8%	0.000
S7.3	Employees are constantly rotated to perform many different tasks.	112	82.4%	2	1.5%	22	16.2%	0.000
S7.4	Sufficient training is provided to multi-skill employees.	105	77.2%	7	5.1%	24	17.6%	0.000
S7.5	Employees are rewarded for learning new skills.	119	87.5%	5	3.7%	12	8.8%	0.000
S7.6	Multi-skilled employees are given the opportunity to perform job rotation.	111	81.6%	9	6.6%	16	11.8%	0.000

Figure 4.7 below graphs the results for integrated functions' responses.

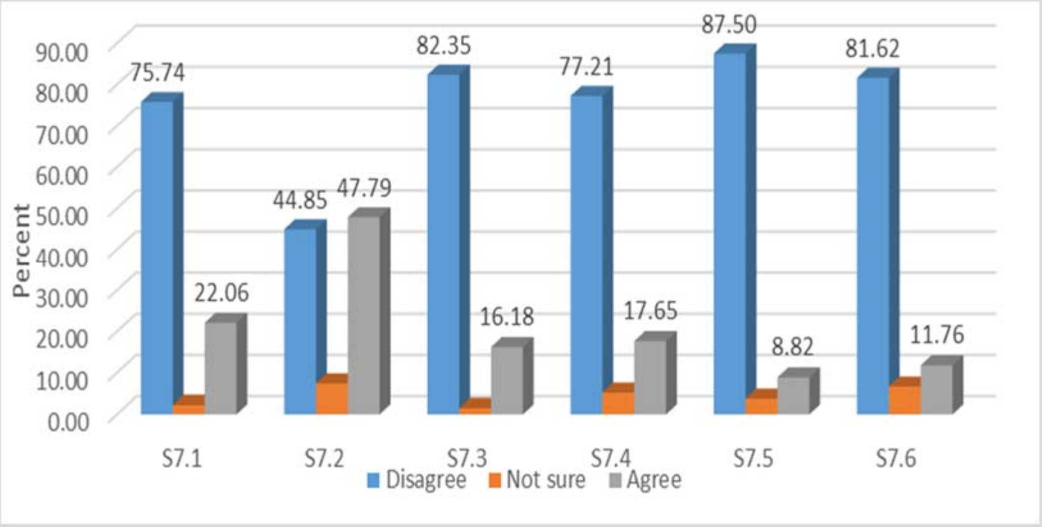

Figure 4.7: Responses to section on integrated functions

The following patterns in the data were observed:

i. five of the questions within this section had significantly high levels of disagreement with the statement being made by the question; and
ii. one question had a significantly high level of agreement with the statement being made by the question.

The significance of the differences is tested and shown in the table 4.9.

The sub-theme of stagnation in skills becomes evident through the high levels of disagreement within this section and it shows that employees are not being allowed to increase their skills and work capacity. Therefore, they are not allowed any room for growth within their area of employment. There is also a lack of training and employees feel that they will benefit from participating in more than one area of the manufacturing process.

4.5.8 Question 8: Vertical Integrated Systems

This section discusses vertical information systems within lean manufacturing.

Vertical information systems is also a principle related to how efficient a multifunctional team is capable of being as it refers to the flow of communication within a lean manufacturing environment and aligns the performance of teams in accordance with the goals that an organisation hopes to achieve (Mund, 2011).

Table 4.10 depicts the results for vertical information systems' responses.

Table 4.10: Responses to section on vertical integrated systems

		Disagree		Not sure		Agree		Chi-Square
Section	Questions	Response Count	Row N %	Response Count	Row N %	Response Count	Row N %	p-value
S8.1	The organisation is transparent in all aspects of the business.	46	33.8%	4	2.9%	86	63.2%	0.000
S8.2	Strategic information such as the organisations market plans, and financial performance is provided to all employees.	59	43.4%	4	2.9%	73	53.7%	0.000
S8.3	Operational information such as productivity, timeliness and quality is provided to all employees.	100	73.5%	8	5.9%	28	20.6%	0.000
S8.4	Information is continually displayed in dedicated spaces, directly in the production flow and this is discussed at regular meetings.	96	70.6%	14	10.3%	26	19.1%	0.000
S8.5	Visual communication is common throughout each process.	86	63.2%	14	10.3%	36	26.5%	0.000

Figure 4.8 below graphs the results for vertical integrated functions' responses

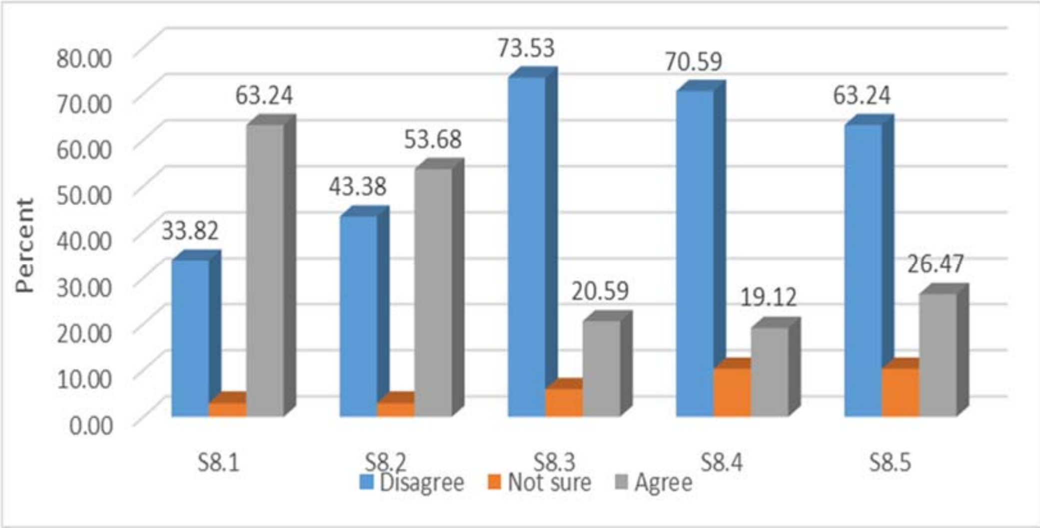

Figure 4.8: Responses to section on vertical integrated functions

The following patterns were observed:

i. three questions had high levels of disagreement with the statement being made in the question; and
ii. two of the questions in this section had high levels of agreement with the statements made in the question.

The significance of the differences is tested and shown in the table 4.10.
While the participants felt that the organisation was transparent on all aspects related to the business itself and were, therefore, satisfied, the development of the sub-theme of provision of information shows that employees are not provided with physical manifestations of information regarding the business. Moreover, there is no designated space or forms of visual communication to keep employees up-to-date on aspects regarding the manufacturing process.

A chi-square test was conducted to determine whether the scoring pattern for each statement was significantly different in comparison with other options in the same question. In terms of the null hypothesis, around the same number of respondents scored across each option per question. On the contrary, the alternate hypothesis states that there is a significant difference between the levels of agreement and disagreement. The aforementioned results are illustrated in table 4.10. The highlighted significant values (p-values) are less than 0.05, which implies

that the distributions were different, i.e., the differences in the manner in which respondents scored (agree, not sure, disagree) were significant.

4.5.9 Question 9: Pull Instead of Push

This section deals with the lean manufacturing principle pull instead of push.

According to Hopp and Spearman (2004), pull is a term referred to the manufacturing of stock in accordance with the needs and supply required by the customer. All material required for the manufacturing of the stock is scheduled accordingly and within the ratio that it is required to complete the order of the product. Push, on the other hand, refers to stock that is manufactured without consideration of the actual amount required by the customer. This means that there is no need to control the material being used and how it should be co-ordinated in accordance with the amount that is required (Hopp and Spearman, 2004)

Table 4.11 depicts the results for pull instead of push responses.

Table 4.11: Responses to section on pull instead of push

		Disagree		Not sure		Agree		Chi-Square
Section	Questions	Response Count	Row N %	Response Count	Row N %	Response Count	Row N %	p-value
S9.1	All employees within the organisation have profound knowledge on how the pull system works.	111	81.6%	10	7.4%	15	11.0%	0.000
S9.2	The organisation manufactures products to actual customer demand rather than to forecasts.	7	5.1%	7	5.1%	122	89.7%	0.000
S9.3	Each workstation pulls the output from the preceding process as it is needed during production.	100	73.5%	9	6.6%	27	19.9%	0.000
S9.4	A Kanban card system is used to signal material replenishment.	104	76.5%	12	8.8%	20	14.7%	0.000
S9.5	Small lot quantities are used as a strategy to detect defects faster.	98	72.1%	13	9.6%	25	18.4%	0.000

Figure 4.9 below graphs the results for pull instead of push responses.

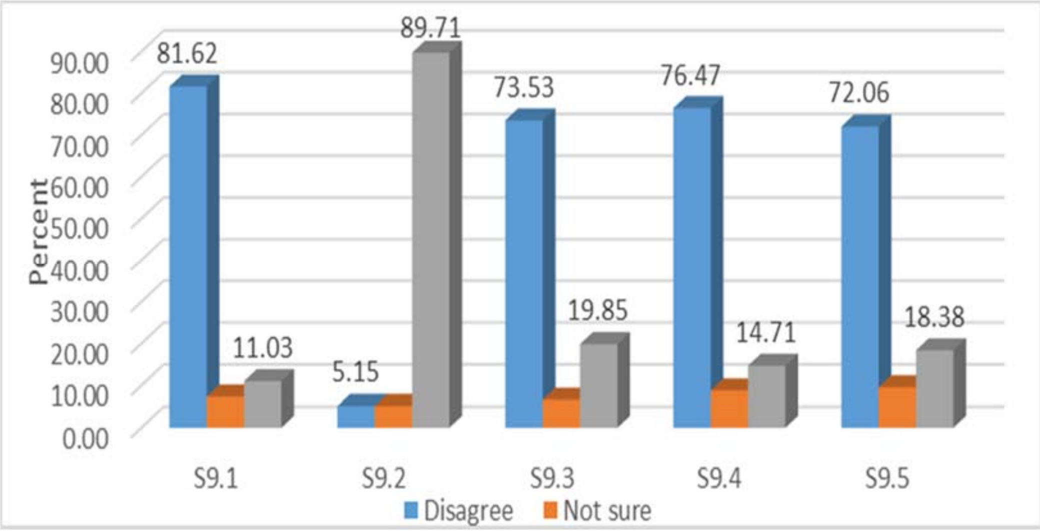

Figure 4.9: Responses to section on pull instead of push

The following patterns were observed within the data:

i. four of the questions within this section displayed significantly high levels of disagreement with the statement being made by the question; and
ii. one statement showed a significantly high level of agreement with the statement being made within the question.

The significance of the differences is shown and tested within the table 4.11.
The data obtained showed that participants lacked knowledge on how the pull and push system within lean manufacturing functions. It also showed that there was no effective pull system implemented within the manufacturing process at Altech UEC. This could prove to be a problem relating to a smooth and efficient flow of production. The statement that had significantly high levels of agreement indicates that the amount of product being produced matches the demand, which indicates an effective management and utilization of resources and manufacturing processes.

A chi-square test was conducted to determine whether the scoring pattern for each statement was significantly different in comparison with other options in the same question. In terms of the null hypothesis, around the same number of respondents scored across each option per question. On the contrary, the alternate hypothesis states that there is a significant difference between the levels of agreement and disagreement. The aforementioned results are illustrated in table 4.11. The highlighted significant values (p-values) are less than 0.05, which implies

that the distributions were different, i.e., the differences in the manner in which respondents scored (agree, not sure, disagree) were significant.

4.5.10 Question 10: Visual Management

This section of the questionnaire discusses the visual management system that exists within the workplace.

The visual management of a work place makes reference to a work environment in which all employees working within a manufacturing process understand that the physical space in which they conduct their work must be kept in an organized manner and managed by employees so that their work is carried out in a secure and neat environment (Vermaak 2008).

Table 4.12 depicts the results for visual management responses.

Table 4.12: Responses to section on visual management responses

		Disagree		Not sure		Agree		Chi-Square
Section	Questions	Response Count	Row N %	Response Count	Row N %	Response Count	Row N %	p-value
S10.1	At our plant we are concerned about keeping all components, tools and instrument in their place.	8	5.9%	2	1.5%	126	92.6%	0.000
S10.2	Our areas are clean and tidy.	5	3.7%	3	2.2%	128	94.1%	0.000
S10.3	There are updated graphs near the equipment indicating down time	92	67.6%	9	6.6%	35	25.7%	0.000
S10.4	There are updated graphs near the work station indicating defects.	101	74.3%	7	5.1%	28	20.6%	0.000
S10.5	There are updated graphs near the work station indicating production level	96	70.6%	9	6.6%	31	22.8%	0.000

Figure 4.10 below graphs the results for visual management responses.

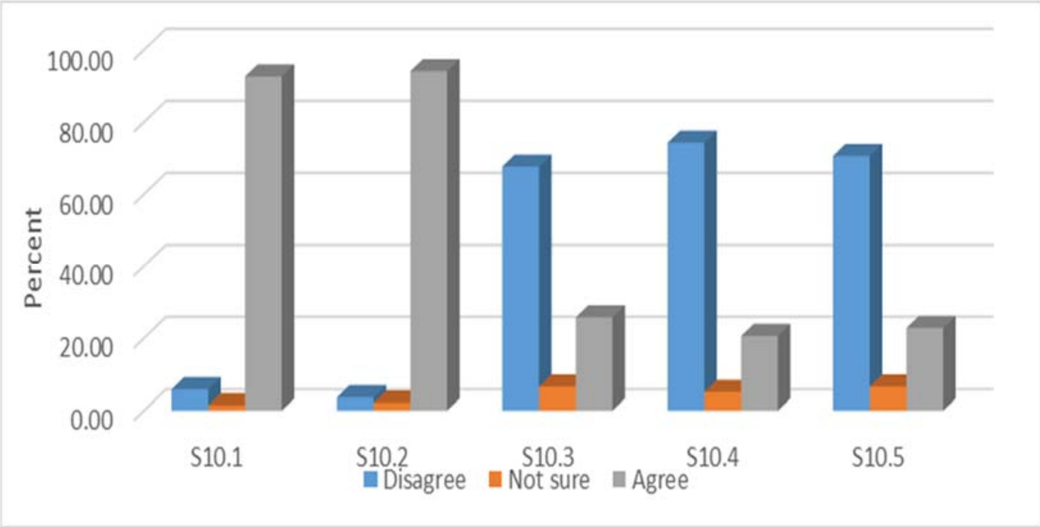

Figure 4.10: Responses to section on visual management

The following patterns were observed:

i. three statements of this section showed significantly high levels of disagreement; and
ii. two statements of this section showed significantly high levels of agreement with the question.

The significance of the differences is tested and shown in the table 4.12.
Participants indicated that there was a fairly high level of interest and effort that went into ensuring that their personal work space was clean and organized at any given time so that they were able to carry out their work effectively and had eliminated all waste within their immediate work environment. Employees' disagreements form a theme in which there was a lack of information given to participants regarding the level of progress that they should have made to the rate of production at any given time.

A chi-square test was conducted to determine whether the scoring pattern for each statement was significantly different in comparison with other options in the same question. In terms of the null hypothesis, around the same number of respondents scored across each option per question. On the contrary, the alternate hypothesis states that there is a significant difference between the levels of agreement and disagreement. The aforementioned results are illustrated in table 4.12. The highlighted significant values (p-values) are less than 0.05, which implies

that the distributions were different, i.e., the differences in the manner in which respondents scored (agree, not sure, disagree) were significant.

4.5.11 Question 11: SMED

This section deals with the lean manufacturing principle of SMED.

SMED is an acronym for Single-Minute Exchange Dies, and is a reference to an operations system that allows for the drastic reduction in the amount of time it takes for equipment to be changed over. It strives to reduce the time required to change over equipment to singular units of time instead of the double unit it takes traditional manufacturing processes (Mokhalimetso, 2011).

Table 4.13 depicts the results for SMED responses.

Table 4.13: Responses to section on SMED

		Disagree		Not sure		Agree		Chi-Square
Section	Questions	Response Count	Row N %	Response Count	Row N %	Response Count	Row N %	p-value
S11.1	An effort is made to reduce the time spent for change overs.	6	4.4%	4	2.9%	126	92.6%	0.000
S11.2	Workers are trained to make quick batch changes and they practise to reduce the time they invest in the task.	96	70.6%	8	5.9%	32	23.5%	0.000
S11.3	Managers give importance to batch change time reduction.	100	73.5%	11	8.1%	25	18.4%	0.000
S11.4	The machinery used is always ready to be used in manufacturing.	100	73.5%	7	5.1%	29	21.3%	0.000

Figure 4.11 below graphs the results for SMED responses.

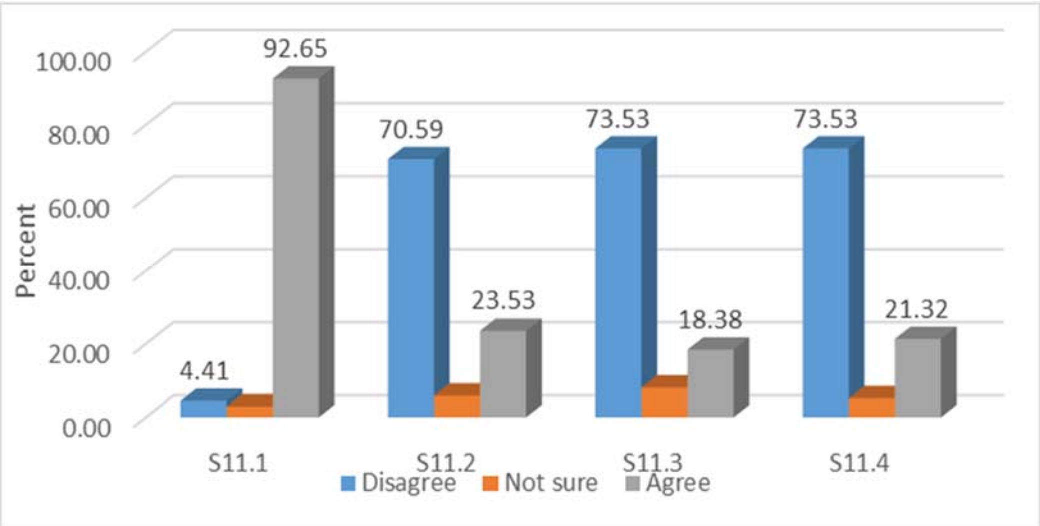

Figure 4.11: Responses to section on SMED Responses

The following patterns were observed:

i. of the four questions within this section, three questions had significantly high levels of disagreement with the statement being made by the question; and
ii. one statement within this section showed significantly high levels of agreement.

The significance of the differences is tested and shown within the table 4.13.
The data showed that the change over time between shifts was effective while there was also a lack of effective communication between managers and employees with regards to the importance managers give to the information pertaining to the batch time changing. There was also a lack of training on how to make quick batches and there was a delay in the readiness of machinery used in the manufacturing process for batching changeovers.

A chi-square test was conducted to determine whether the scoring pattern for each statement was significantly different in comparison with other options in the same question. In terms of the null hypothesis, around the same number of respondents scored across each option per question. On the contrary, the alternate hypothesis states that there is a significant difference between the levels of agreement and disagreement. The aforementioned results are illustrated in table 4.13. The highlighted significant values (p-values) are less than 0.05, which implies that the distributions were different, i.e., the differences in the manner in which respondents scored (agree, not sure, disagree) were significant.

4.5.12 Question 12: Supplier relations

This portion of the questionnaire examines supplier relations.
The relationship between a supplier of a product and the organisation buying the product is often competitive as each party seeks to cover their own interests. Within a lean manufacturing organisation, there are several aspects and criteria that have to be met for the relationship between a supplier and buyer to be successful (Duiker, 2014).

Table 4.14 depicts the results for supplier relations responses.

Table 4.14: Responses to section on supplier relations

		Disagree		Not sure		Agree		Chi-Square
Section	Questions	Response Count	Row N %	Response Count	Row N %	Response Count	Row N %	p-value
S12.1	A clear strategy is in place by which to evaluate supplier performance in terms of quality, delivery and price.	2	1.5%	12	8.8%	122	89.7%	0.000
S12.2	Local suppliers are used to avoid shipment deliveries.	79	58.1%	16	11.8%	41	30.1%	0.000
S12.3	Raw materials are received on time from date of orders.	8	5.9%	19	14.0%	109	80.1%	0.000
S12.4	Suppliers are provided with feedback regarding quality and delivery.	5	3.7%	20	14.7%	111	81.6%	0.000
S12.5	Raw materials and purchased parts are not subject to incoming inspection.	102	75.0%	11	8.1%	23	16.9%	0.000

Figure 4.12 below graphs the results for supplier relations responses.

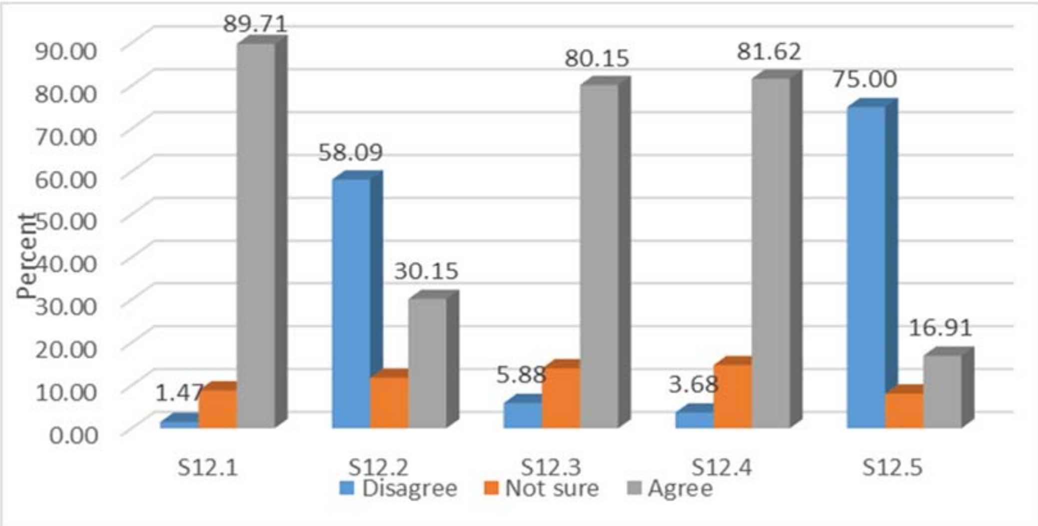

Figure 4.12: Responses to section on supplier relations

The following patterns were observed:

i. three of the questions within this section showed significantly high levels of agreement; and
ii. two of the questions within this section displayed significantly high levels of disagreement with the statement being made by the question.

The significance of the differences have been tested and are shown within table 4.14.

The data show that there is a timeous and efficient delivery and an open level of communication that exists with suppliers. It also shows that suppliers are not local which could pose a problem with local supplier relations. There is no inspection system in place to ensure that no parts are defective which could prove detrimental to the manufacturing process should a malfunction occur as a result of a faulty part that was purchased from a supplier.

A chi-square test was conducted to determine whether the scoring pattern for each statement was significantly different in comparison with other options in the same question. In terms of the null hypothesis, around the same number of respondents scored across each option per question. On the contrary, the alternate hypothesis states that there is a significant difference between the levels of agreement and disagreement. The aforementioned results are illustrated in table 4.14. The highlighted significant values (p-values) are less than 0.05, which implies that the distributions were different, i.e., the differences in the manner in which respondents scored (agree, not sure, disagree) were significant.

4.5.13 Question 13: Customer Relations

This section looks at customer relations within a lean manufacturing context.

According to Taj (2008), one of the most important principles in lean manufacturing is the possession of complete respect for all people and continuously improving relations with the different individuals who have a part in the manufacturing process which includes individuals who purchase the product that is created by the lean manufacturing process, known as the customer or client of that organisation.

Table 4.15 depicts the results for customer relations responses.

Table 4.15: Responses to section on customer relations

		Disagree		Not sure		Agree		Chi-Square
Section	Questions	Response Count	Row N %	Response Count	Row N %	Response Count	Row N %	p-value
S13.1	We have close work relationships with our customers (frequent and direct contact, mutual visits to our respective plants, collaboration agreements).	8	5.9%	9	6.6%	119	87.5%	0.000
S13.2	We survey or diagnose our customers' needs or requirements.	36	26.5%	12	8.8%	88	64.7%	0.000
S13.3	Our organisation processing is integrated with that of the customer.	37	27.2%	16	11.8%	83	61.0%	0.000
S13.4	Customers provide us with feedback on product quality, delivery and timing.	3	2.2%	17	12.5%	116	85.3%	0.000

Figure 4.13 below graphs the results for customer relations responses.

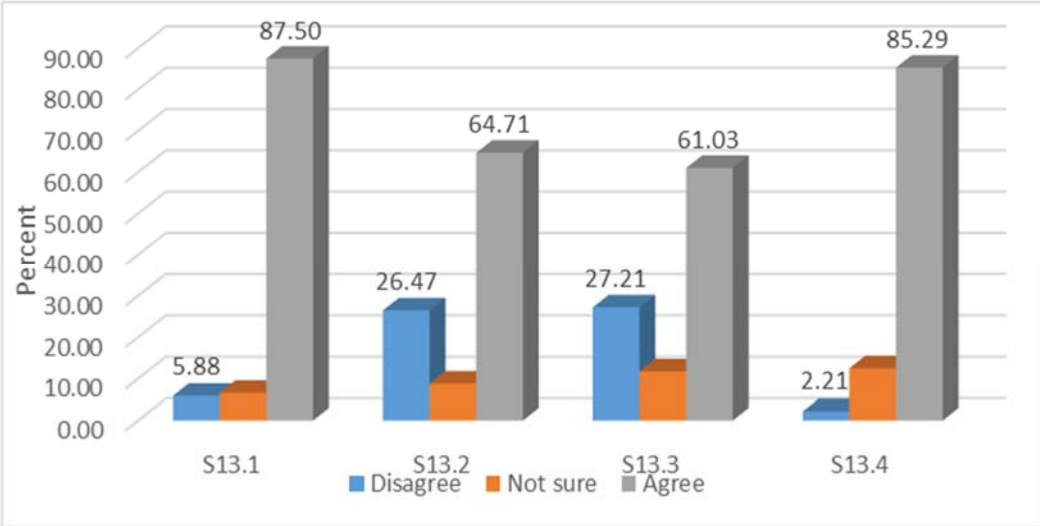

Figure 4.13: Responses to section on customer relations

The following patterns were observed:

i. all five statements within this section displayed significantly high levels of agreement.

The significance of these differences is tested and shown in the table 4.15.

The pattern observed shows that the needs of customers are taken care of by employees and that there are a number of systems in place to ensure that customers are able to provide a sufficient level of feedback on how the process of meeting their needs can be improved. It also shows that all processes within the organisation that takes the needs of the customer into consideration and sees it as the organisation's top priority.

A chi-square test was conducted to determine whether the scoring pattern for each statement was significantly different in comparison with other options in the same question. In terms of the null hypothesis, around the same number of respondents scored across each option per question. On the contrary, the alternate hypothesis states that there is a significant difference between the levels of agreement and disagreement. The aforementioned results are illustrated in table 4.15. The highlighted significant values (p-values) are less than 0.05, which implies that the distributions were different, i.e., the differences in the manner in which respondents scored (agree, not sure, disagree) were significant.

4.5.14 Question 14: Knowledge Management

This section deals with the management of knowledge within the organisation.

Most organizations who implement lean manufacturing only take into account the more technical applications of lean manufacturing and fail to see the extensive range that is covered by lean as a concept which can also be applied to knowledge management. Knowledge, according to Davenport (1998, in Dumbrowski and Engel, 2012:437) can be defined as "a fluid mixture of framed experience, values, contextual information, and expert insight that provides a framework evaluating and incorporating new experiences and information".

Table 4.16: depicts the results for knowledge management responses.

Table 4.16: Responses to section on knowledge management

		Disagree		Not sure		Agree		Chi-Square
Section	Questions	Response Count	Row N %	Response Count	Row N %	Response Count	Row N %	p-value
S14.1	In the organisation there are regulations supporting innovative ideas research and exploitation.	94	69.1%	14	10.3%	28	20.6%	0.000
S14.2	We use information systems or data bases that allow knowledge to widespread through the organisation.	85	62.5%	5	3.7%	46	33.8%	0.000
S14.3	There are groups of workers that continuously have access, put into practice and update their working knowledge.	93	68.4%	12	8.8%	31	22.8%	0.000
S14.4	We use formal mechanisms in order to share the best practices amongst the organisation's personnel.	99	72.8%	9	6.6%	28	20.6%	0.000

Figure 4.14 below graphs the results for knowledge management responses.

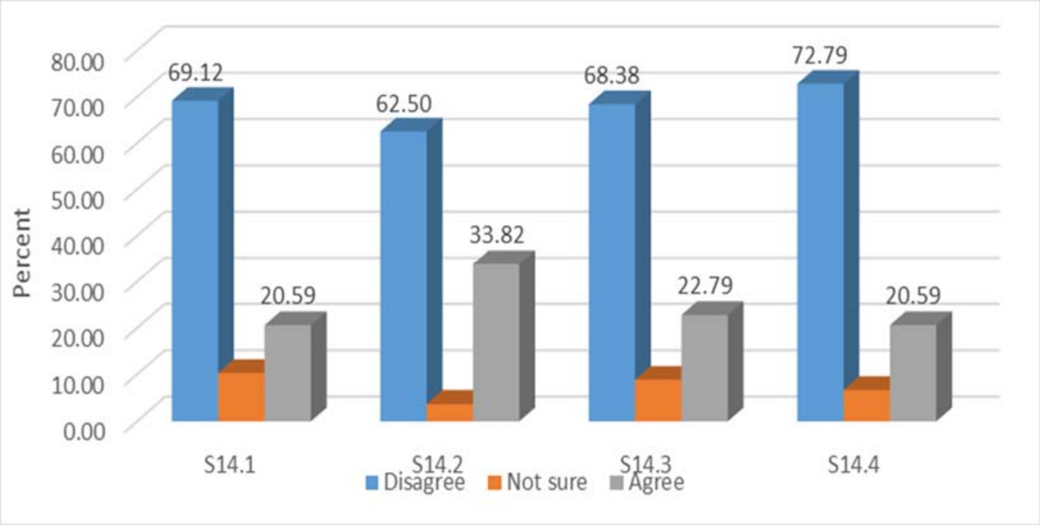

Figure 4.14: Responses to section on knowledge management

The following patterns were observed:

i. all four questions within this section displayed significantly high levels of disagreement with the statement being made in each of the questionnaires.

The significance of these differences has been tested and is shown within the table 4.16.
The data obtained shows that there is no format or system that allows for the production or innovation of information to improve the manufacturing systems that are currently in use by the organisation in question. It also shows that information is limited and only distributed according to the area, which limits the growth of knowledge for each department. There are no systems in place that allow for employees to share information with each other.

A chi-square test was conducted to determine whether the scoring pattern for each statement was significantly different in comparison with other options in the same question. In terms of the null hypothesis, around the same number of respondents scored across each option per question. On the contrary, the alternate hypothesis states that there is a significant difference between the levels of agreement and disagreement. The aforementioned results are illustrated in table 4.16. The highlighted significant values (p-values) are less than 0.05, which implies that the distributions were different, i.e., the differences in the manner in which respondents scored (agree, not sure, disagree) were significant.

The matrix tables are preceded by a summarised table that reflects the results of KMO and Bartlett's Test. The requirement is that Kaiser-Meyer-Olkin Measure of Sampling Adequacy should be greater than 0.50 and Bartlett's Test of Sphericity less than 0.05 (IBM, 2017). In all instances, the conditions are satisfied which allows for the factor analysis procedure.

Factor analysis was done only for the Likert scale items (Q3.1.1- Q3.14.4).

The table below depicts the results for the KMO Bartlett's Test.

Table 4.17: KMO Bartlett's Test

No.	Questions	Kaiser-Meyer-Olkin Measure of Sampling Adequacy.	Bartlett's Test of Sphericity		
			Approx. Chi-Square	df	Sig.
1	Elimination of Waste	0.745	477.775	28	0.000
2	Continuous Improvement	0.813	520.003	28	0.000
3	Zero Defects	0.528	139.293	15	0.000
4	Just in time	0.847	386.662	10	0.000
5	Multifunctional teams	0.783	423.077	21	0.000
6	Decentralised responsibilities	0.767	175.531	10	0.000
7	Integrated functions	0.834	282.002	15	0.000
8	Vertical information systems	0.684	223.982	10	0.000
9	Pull Instead of Push	0.816	344.647	10	0.000
10	Visual Management	0.721	375.115	10	0.000
11	SMED	0.727	307.363	6	0.000
12	Supplier Relations	0.689	183.373	10	0.000
13	Customer Relations	0.476	136.789	6	0.000
14	Knowledge Management	0.819	285.756	6	0.000

All of the conditions are satisfied for factor analysis.

That is, the Kaiser-Meyer-Olkin Measure of Sampling Adequacy value should be greater than 0.500 and the Bartlett's Test of Sphericity sig. value should be less than 0.05. For Kaiser-Meyer-Olkin, the results varied between 0.476 – 0.847 and the Bartlett's Test of Sphericity value was 0.000.

The principle component analysis was used as the extraction method, and the rotation method was Varimax with Kaiser Normalization. This is an orthogonal rotation method that minimizes the number of variables that have high loadings on each factor. It simplifies the interpretation of the factors.

Items of questions that loaded similarly imply measurement along a similar factor. An examination of the content of items loading at or above 0.5 (and using the higher or highest loading in instances where items cross-loaded at greater than this value) effectively measured along the various components.

The statements that constituted Questions 4, 6, 7, 9, 13 and 14 loaded perfectly along a single component. This implies that the statements that constituted these sections perfectly measured what it set out to measure. It is noted that the variables of the remaining questions loaded along 2 or 3 components (sub-themes). This means that respondents identified different trends within the section. Within the section, the splits are colour coded to show the comparison between questions.

Table 4.18: Rotated Component Matrix Colour Code Analysis

Question no.	Yellow	Green	Peach
1	Time taken by production processes	Quality of processes involved in the manufacturing process	
2	Level of employee training	Process methodology	
3	Management of defective parts	Responsibility of operators	Inspection and management of quality control
4	Rate efficiency of processes		
5	Implementation of multifunctional teams	Employee responsibility	Number of employees in multifunctional teams
6	Responsibility of operators and management		
7	Rotation of jobs and responsibilities		

8	Communication of information	Business information transparency	
9	Knowledge of push and pull		
10	Updating of information graphs	Neatness of work stations	
11	Batching rates	Rate of change overs	
12	Communication with supplier	Quality of supplied goods	
13	Customer relations		
14	Quality of knowledge		

4.6 Reliability Statistics

The two most important aspects of precision are **reliability** and **validity**. Reliability is computed by taking several measurements on the same subjects. A reliability coefficient of 0.600 or higher is considered as “acceptable” for a newly developed construct (IBM, 2017).

Table 4.19 below reflects the Cronbach’s alpha score for all the items that constituted the questionnaire.

Table 4.19: Reliability Statistics for Questions

No.	Question	Number of Items	Cronbach's Alpha
1	Elimination of Waste	8 of 8	0.747
2	Continuous Improvement	8 of 8	0.765
3	Zero Defects	5 of 6	0.475
4	Justintime	5 of 5	0.893
5	Multifunctional teams	7 of 7	0.771
6	Decentralised responsibilities	5 of 5	0.750
7	Integrated functions	6 of 6	0.816
8	Vertical information systems	4 of 5	0.752
9	Pull Instead of Push	5 of 5	0.729
10	Visual Management	5 of 5	0.701
11	SMED	4 of 4	0.789
12	Supplier Relations	4 of 5	0.197
13	Customer Relations	3 of 4	0.698
14	Knowledge Management	4 of 4	0.879

The reliability scores for all but 2 sections exceed the recommended Cronbach’s alpha value. This indicates a degree of acceptable, consistent scoring for these sections of the research.

Questions 3 and12 had values that were below the minimum score.

4.7 Conclusion

The research found that significant results were achieved in the understanding and perceptions that employees have of lean manufacturing and lean manufacturing principles. It found that employees had a comprehensive understanding of what was required for a manufacturing organisation to be seen as compliant with lean manufacturing principles. However, the organisation itself was found to be non-compliant with lean manufacturing principles and there is a serious lack of lean manufacturing principle integration with the functions and processes involved in the manufacturing organisation.

The next chapter will review the results and use the relevant literature to discuss points of interest that pertain to the study as a whole.

CHAPTER 5

DISCUSSION OF RESULTS AND RECOMMENDATIONS FOR FUTURE RESEARCH AND CONCLUSION

5.1 Introduction

The preceding chapter examined the results obtained from the data collected from the study and analysed them using a number of quantitative methods. This chapter will review each question and the result according to the context of the research questions of the study and will examine these results in relation to the support provided by previous literature. This study is guided by the following research questions:

- What are the perceptions of employees of lean manufacturing and the principles that they believe have been implemented within Altech UEC?
- What is the impact being made or lack thereof of implementing lean manufacturing at Altech UEC?
- What are the challenges being faced by the implementation of lean manufacturing at Altech UEC?
- What are the ways in which the implementation of lean manufacturing can be improved within Altech UEC?

5.2 Elimination of Waste

The elimination of waste refers to the removal of unnecessary processes and materials from the lean manufacturing process that serve no vital function (Scholtz, 2008).

Respondents were asked if work in progress inventory is kept to a minimum (Q3.1.1). It was found that, while Altech UEC has forms of waste elimination, work-in-progress, that is work that is left to do at a later stage, was found to be one of the processes used at Altech UEC. Duiker (2014) found that this is not conducive to an efficient work environment and accumulates waste as it allows for build-up of processes that still need to be completed for a product to be produced. The study found that parts are only delivered according to the demand by customers for the product which means that no excess stock is being kept on site. AbuShaaban (2012) found that this is a crucial part of the waste elimination process as ordering stock only when it is required ensures that there is no excessive stock kept on hand which would waste productivity space. The study found that large lot sizes, a prolonged amount of time used to transport parts and lengthy distances from one manufacturing cell to another resulted in waste that could negatively affect the manufacturing process. Nhlabathi (2013) found that problems such as the lot size and the failure to monitor defective goods, reduce the productivity of an organisation. Therefore Altech UEC has not effectively implanted a waste elimination component into the manufacturing process.

The impact of lean manufacturing within an organisation has a number of benefits. Inspection of parts and processes ensures that the continuous removal of waste from the manufacturing process is maintained (AbuShaaban, 2012). Respondents were asked if lot sizes are continuously monitored and reduced to keep inventory down (Q3.1.3) and it was found that lot sizes were monitored to ensure that the amount of inventory on site was kept to a minimum. Scholtz (2008) showed that a product kept within inventory loses the quality that it had when it was originally manufactured, and cannot be sold to customers thereby resulting in wastage. The reduction of manufacturing cycle times also means that a product is constantly and efficiently being produced. If the manufacturing process is completed within a smaller time frame, it allows for the manufacturing cycle to be repeated faster, which means that more product will be produced, which indicates that lean manufacturing had a positive impact on the manufacturing process.

The elimination of all waste within Altech UEC has proven to be a challenge. Respondents were asked if manufacturing cycle times are kept to a minimum (Q3.1.6). Responses showed that there is a lack of time management within the manufacturing process as time is wasted on unnecessary processes and tasks that can be improved and completed at a more efficient pace. Pereira (2009) discusses the wait period as a form of waste. The wait period within the context of Altech UEC refers to the delay in the transportation of different parts to the manufacturing cells that need them. Duiker (2014) found that any delay within the manufacturing cells that are responsible for the completion of a product results in a delay of the product being sold to the consumer. Such a delay results in financial strain for the organisation as sales and profits are negatively affected. Pereira (2009) also lists transportation as a form of waste which is also an issue at Altech UEC as the data show that the transportation of parts between cells is delayed because of the distance that exists between manufacturing cells. Nhlabathi (2013) found that in order to eliminate this form of waste, there needs to be an organized and logical order to the way in which manufacturing cells are arranged and that they need to be in close proximity of one another to ensure the efficient movement of parts and materials required for the completion of the manufacturing process.

There are several ways in which the lean manufacturing process can be improved at Altech UEC. The first would for a complete inspection of the manufacturing process by management and members of staff to review ways in which waste can be removed from all processes that require the transport of goods as the data relating to the elimination of waste showed that the distance and time taken for the delivery of parts from one area to another was not at the level that it had the potential to be at. Another way of eliminating waste is to ensure that there is consistent inspection of parts and tools and materials involved in the manufacturing process, that every process occurs at an optimum rate of completion with as much as efficiency in the manufacturing process as possible (AbuShabaan, 2012). Implementing lean manufacturing has proven to provide drastic improvements to the manufacturing process; by improving all aspects of the organisation, such as the purchasing process of goods required for the manufacture of the product. This is evident in the material requirements planning (MRP) system that is use by Altech UEC, where all materials and parts are ordered and purchased according to the need for the product.

5.3 Continuous Improvement

Continuous improvement within the context of lean manufacturing, refers to the streamlining of manufacturing processes and the effort made by management and staff alike to ensure that the manufacturing process is always evolving and constantly being improved with the manufacturing line to minimise waste (Vahed, 2012). While there are some elements of continuous improvement present within the manufacturing process at Altech UEC, there is still a great deal of improvement that is required in this field.

Upon reviewing the responses to Q3.2.1 – Q3.2.8, it is clear that there are some forms of continuous improvement in use. The PDCA (plan-do-check-act) model is used to consistently address problems that are encountered during the manufacturing process. According to Moen and Norman (2006), the PDCA process ensures that a process involved in the manufacturing line is planned before it is carried out. The actual process is then carried and checked for faults. This is one of the lean manufacturing principles in use at Altech UEC. The question to respondents was if the PDCA methodology was consistently used to address problems (Q3.2.7). The responses reveal that the PDCA system is used to ensure that problems are consistently kept under inspection and the appropriate action is taken to address them at any given time. Another method of lean manufacturing in use at Altech UEC is the 5S method. The 5S lean manufacturing principle is a part of the kaizen system that requires that all processes are run against a set of rules for the efficient management of the manufacturing process. Marnewick (2011) lists the principles as ‘being sort’, which refers to the separation of what is needed and what is not, ‘straighten’, which systematically arranges the required parts and materials, and in the order that they are required, ‘shine’, refers to the maintenance of a clean work environment, ‘standardize’, refers to the repetition of the first three steps (being sort, straighten and shine) until they become a permanent part of the manufacturing process and ‘sustain’ indicates that these practices are maintained and are consistently used in the manufacturing process.

Respondents were asked various other questions in terms of continuous practices Q3.2.1-Q3.2.8 and the responses showed that there is very little use made of the various practices that comprise continuous improvement. The organisation could have utilized the first-hand experience of employees in attempting to improve the processes currently in use. Ondiek and Kisombe (2013) found in their study that utilizing employees in the improvement process provides a practical element to the improvements being made to the manufacturing process as employees have invaluable experience with the manufacturing processes and have an in-depth knowledge of the materials and parts that can be removed as waste to streamline processes within the manufacturing of the product. Another way in which the lean manufacturing principle ‘continuous improvement’ impacts on the manufacturing process is that it allows for all employees to be involved with the continuous improvement process and is not just limited to management or supervisors. By not utilising continuous improvement, the organisation limits itself to generic solutions that are not contextualized according to the needs of the organisation. Therefore, The manufacturing process is not brought to optimum efficiency and limits the capabilities of the organisation’s employees to utilise the full of spectrum of their capabilities in manufacturing the maximum amount of products possible within a single manufacturing cycle (Karlssom and Ahlstrom, 1996).

The problem with implementing processes that are a part of the continuous improvement principle is that there are costs involved with ensuring continuous improvement. This could be one of the reasons why there is very little utilization of the continuous improvement principle at Altech UEC. Rahman, Laosirihongthong and Sohal (2010) found that the reluctance of a large number of manufacturing companies in implementing lean manufacturing is as a result of the calculated costs required to effectively implement lean manufacturing as a business strategy and manufacturing style. This could also be one of the reasons why employees have not received training as the calculated amount may be out of the budget for the organisation. Ondiek and Kisombe (2013), however, suggest that the organisation should restructure the way in which business is carried out as there are smaller costs within a business that can be eliminated from the business budget which can make way for the implementation of lean manufacturing. Due to the lack of continuous improvement initiatives a lack of feedback exists with regards to the improvements that are required for the manufacturing process and all the systems that are involved. In order to remedy this lack, Vahed (2012) suggests that companies have a weekly or monthly meeting for each section and department and problems that were faced for that period of time are discussed by staff, employees and management to provide a viable and practical solution with long lasting effects to remedy it.

There are a number of ways in which the lean manufacturing principle of continuous improvement can be better utilized and modified to suit the needs of Altech UEC. Respondents were asked, if their views are never underestimated by management (Q3.2.2). Employees indicated that the manufacturing processes used by the organisation are not being fully utilized by management in continuously improving how production continues at Altech UEC. Makhomu (2012) found that not including staff in decisions that affect the manufacturing process, can have a negative impact on employee morale, which in turn, affects the working capacity of employees and negatively impacts on their ability to work at optimum efficiency. There is also a lack of training provided to employees on how to continuously improve on the manufacturing process. By not providing the sufficient amount of training to employees, their capabilities and improvements that they are capable of making to the manufacturing process are inhibited (Wen, 2006). By including employees in every step of improving the manufacturing process, it allows them to gain the necessary experience and motivation to contribute to methods that will further reduce waste and optimize the manufacturing process. This allows for employees to eventually make decisions and inspect the manufacturing process without requiring supervision or instructions from management (Vahed, 2012).

5.4 Zero Defects

Zero defects is a lean manufacturing concept that becomes a work ethos and checklist against which the manufacturing process is carried out, Soriano-Meier and Forrester (2002) look at zero defects as a mentality taken on by employees so that all processes involved in the manufacturing process are incapable of producing goods and parts that are of poor quality and which will later affect the product being manufactured negatively.

Respondents were asked Q3.3.1 – Q3.3.7. The evidence shows that there are several components of zero defects that are in effect at Altech UEC. One component of zero defects ensures that operators within the lean manufacturing process are responsible for identifying defective parts at the source of the operation. Therefore no parts that may be detrimental to the manufacturing process are allowed into the manufacturing process and the quality of the product does not diminish (Arsuaga Berrueta, Ortiz, Lobato, Valdivielso, Lopez De Lacalle, 2012). Altech UEC also implements a system which ensures that all measuring and inspection required for the assurance of quality retention is carried out at the end of each manufacturing process.

Anwari, Ismail and Hajjati (2011) found that such a system ensures that the level of quality of the product is maintained at a fairly high level and that the level of quality is not diminished as the manufacturing process progresses towards the final product. By placing operators in charge of the quality of the goods used in the manufacturing process and in charge of the quality of the final product, the individuals involved become extensively familiar with the quality of goods being produced which means that they are then aware of what is required to ensure that a high quality level for the goods being produced is retained Rahman, Laosirihongthong and Sohal (2010).

It is clear from (Q3.3) that the principles of zero defects had a positive impact on the manufacturing process at Altech UEC. The use of systematic methods in reviewing and inspecting the manufacturing process provides no room for a fault to be missed or for a fault to be made. Nawanir,Teong and Othman (2013) found that an autonomous defect control systems ensures that all possible faults are anticipated and a contingency plan is put into place so that these faults do not occur. It also regulates and inspects the parts involved with the manufacturing process so that no faults occur and that each part within the manufacturing process is kept at a sufficient quality level for efficient functioning (Anwari et al, 2011). The measurement of parts and processes involved in the final products is also evidence of the positive impact that lean manufacturing principles has had on the manufacturing process. Every part of the product and process retains a fairly high level of quality and if any part does not match the quality management criteria of the organisation, it is removed and replaced within the process which ensures that the quality of the product is not affected by any defective parts within the manufacturing process (Arsuaga Berrueta et al., 2012).

While there has been a number of zero defects components implemented as a part of the manufacturing process, there are still several areas that have yet to be addressed. The first area is that operators are not allowed or are not able to stop the manufacturing line if a defective part of resource was identified within the manufacturing process. Cwiklicki (2016) found that allowing for a defective part to pass through the manufacturing process could result in the defect affecting the quality of the product and could create a product that is diminished in terms of quality which then diminishes the monetary value possessed by the product. Another area, in which the implementation of zero defects was lacking and therefore posed a challenge to the implementation of lean manufacturing within Altech UEC, was in the handling of defective parts and goods. Parts that were found to be defective were not repaired or reworked at the work station at they were discovered but instead were removed and repaired elsewhere. This poses a problem because, by not repairing the part where it was found, it then a number of different of wastes in the form of time and transport and stalls the entire manufacturing process. Thus, the time taken for the manufacturing cycle to be completed is affected and the number of product that is produced in a day is reduced (Soriano-Meier and Forrester, 2002).

While there has several components of zero defects integrated into the manufacturing process at Altech UEC, there are still several ways in which they can be improved. The first is the inclusion of a system that allows for defective parts to be reworked at the manufacturing cell in which it is located. A possible solution entails training the employees involved in each manufacturing cell to effectively deal with malfunctions or defects that may occur during the process that they are carrying out. This ensures that employees have a multi-skill level and can function without requiring external assistance in dealing with a fault (Anwari, 2011). Another way in which it can be improved, within the context of Altech UEC, is to give more than one person the ability to stop the manufacturing line and carry out a quality management inspection that all parts and materials are of the required quality. Consequently, should something go wrong or malfunction during the manufacturing process, it can be addressed and rectified immediately Rahman, Laosirihongthong and Sohal (2010).

5.5 Just-in-time

Chen and Tan (2013) defines just-in-time processes as a method of inventory used by companies which decreases waste in the form of excess stock and increases efficiency of the manufacturing process by only producing goods according to the needs of the consumer. Just-in-time reduces space wasted as inventory and ensures that no material and resources are wasted in the manufacture of more stock than is actually required.

There are no just-in-time processes or principles currently in use at Altech UEC. This lack is reflected by the questions Q3.4.1 – Q3.4.5 to which respondents strongly disagreed. This shortcoming can pose a problem to the organisation due to the benefits represented by the implementation of the just-in-time processes and the problems that can arise should it not be implemented alongside the other principles that are a part of lean manufacturing. Just-in-time processes allow for the manufacturing process to be refined and processes are continuously improving on the amount of waste that is expelled during the manufacturing process (Bayo-Moriones, Bello-Pintado, Merino-Dı´az-de-Cerio, 2008). As there are no just-in-time components currently being implemented to improve the manufacturing process at Altech UEC, it can be presumed, based on the responses to questions Q3.4.1 – 3.4.5, that there is an extensive area in use for the inventory levels are higher than necessary and there is no proactive attempt by management or staff to effectively reduce turnover times and the rate of manufacturing within each manufacturing cycle. White and Pearson (2001) found that companies with no form of just-in-time system integration experience a decreased level of production and the manufacturing process is not capable of working at optimum efficiency.

Just-in-time processes have proven to have a significant impact on the manufacturing process. Chen and Tan (2013) found that the implementation of the just-in-time systems reduces the wait times for parts between manufacturing cells, which reduces waste in the form of time. This reduction allows for time to be allocated to other areas that require a deeper level of attention and concentration. As Altech UEC does not have any kind of just-in-time system in place, which is shown by the responses to questions Q3.4.1 – Q3.4.5, there is an unnecessary amount of time taken for the transportation of materials and parts between manufacturing cells. Hence, the time taken for the manufacturing process to reach completion increased, and impacts on the amount of products that are produced on a daily basis. Another problem posed by the lack of a just-in-time system is that inventory levels kept at any given manufacturing cell in regards to work that has to be completed or parts that still need to be used is not reduced, where-ever possible. This means that there is an excessive amount of work to complete within any manufacturing cell at any given point in time. Paneru (2011) found that this build of work that has yet to be completed has a negative impact on the quality of the product, as attention is given to both completing processes as they come in and the work that still requires completion. These shortcomings can then have a detrimental on the quality of the work that is produced.

The responses to questions Q3.4.1 – Q3.4.5 show clear evidence of the struggle that Altech UEC has with implementing lean manufacturing principles, particularly that of just-in-time processes and systems. Respondents were asked if production lot sizes, buffer sizes and order lead time are continuously reduced to ensure just in time production (Q3.4.2). The findings show that there is no reduction in production lot sizes and order lead time. This wastage could pose a problem when the product is actually completed and delivered to the consumer. A study conducted by McLachlin (1997) found that larger lot sizes take up space that could be better utilized to break down more extensive manufacturing cells to refine the manufacturing process. Thereby, wastage is reduced per cell instead of reducing the amount of waste after one process. Another system that has not been implemented and could pose a challenge is that each process is not given the required part exactly when it is needed at that specific juncture in the manufacturing process. This also causes a lag within the manufacturing process as it means that a process involved in the manufacturing of the product is delayed until the required part is received. In order to remedy this problem, just-in-time principles need to be applied to the current system of transportation to better manage the way in which parts are delivered and the time in which they are received (Tan, 2013).

There are a large number of improvements that can be made to the implementation of just-in-time processes within the manufacturing process at Altech UEC. The first is devising a practical system that will allow employees within each manufacturing cell to fully complete their workload so that there is no work-in-progress inventory at any given manufacturing cell. This system ensures that there is an efficient and concise flow in the manufacturing process and there is very little or no delays (White and Pearson, 2001). Another way, in which the implementation of just-in-time systems can be effective in improving the manufacturing process at Altech UEC, is by ensuring that the delivery of goods and services by suppliers arrives exactly when it is required by the manufacturing process to move forward as. Respondents were asked if suppliers deliver at the time of consumption (Q3.4.3). It was found that this is not the case currently within the organisation. Supervisors and the employees involved with a particular process can liaise with suppliers and arrange a monthly or weekly schedule to ensure that goods arrive when they are required by the organisation. Therefore, there is no excessive goods and materials being delivered by suppliers and all goods are used for their purpose within the manufacturing process (Tan, 2013).

5.6 Multifunctional Teams

Multifunctional teams are another principle under lean manufacturing that can greatly improve on the manufacturing process. Multifunctional teams is a term that is used to refer to the grouping of employees into manufacturing cells with each employee being able to perform and complete a number of different tasks required for the completion of the manufacturing process (Karlsson and Ahlstrom, 1996).

Respondents were asked questions Q3.5.1 – Q3.5.2. It was found that, while the practical aspects of multifunctional teams have not been utilized, the principles that comprise of multifunctional teams have been applied by employees who work in teams within the numerous manufacturing cells and believe that the number of employees who are a part of a multifunctional team should increase. Respondents were asked if the number of employees in multifunctional teams should increase (Q3.5.2). They responded that there are not enough members within multifunctional teams and that a gap in the number of multi-skilled employees working within any given manufacturing cell exists. Pelled and Adler (1994) found that conflict can often arise between workers who are more skilled than others as a result of training provided by the organisation. Therefore, teamwork is an integral part to ensuring that the manufacturing process runs smoothly and all tasks are collaborated by workers. Respondents were asked if teamwork promotes trust, support, respect and collaboration (Q3.5.7). A large majority of participants believed that teamwork was integral to the success of the manufacturing process. Pelled and Adler (1994) found that conflict arises as employees with a lack of training and expertise feel inferior to those who have received it. This could explain why employees feel that there need to be more employees who are able to perform a number of different functions so that the work dynamic is balanced and there is no hierarchy within teams working in the different manufacturing cells.

The introduction of multifunctional teams into the manufacturing process can have a positive impact on the rate at which work is carried out and the efficiency with which the manufacturing process is managed. Respondents were asked if multifunctional teams exist within the organisation and are arranged at different manufacturing processes (Q3.5.1). The majority of the responses indicate that there are no multifunctional teams that exist within Altech UEC. Their non-existence limits the impact that lean manufacturing as multifunctional teams allow for the creation of teams in manufacturing cells that require a limited number of employees for each cell as each member of the team is able to perform all tasks required for production to be completed within that part of the manufacturing process (Vienazindiene and

Ciarniene, 2013). Multifunctional teams decrease the number of employees required for each manufacturing cell within the manufacturing process as tasks are rotated between each member that is part of a specific team. Since this is not the case within Altech UEC, it limits employees' as they only gain experience performing one specific task within the manufacturing process and do not expand their skill set thus limiting the capabilities of employees and stunting their professional growth (De Vries, 2015).

Altech UEC does not currently have a multifunctional team operation in place to optimise the manufacturing process as evident by responses to question Q3.5.1. This finding poses a challenge to the successful implementation and integration of lean manufacturing as a viable and successful system of function. It limits the training received by employees as their capabilities within the work environment are limited to one specific part of the manufacturing process and they would be unable to effectively address a problem or malfunction within another sector of the lean manufacturing process (Soriano-Meier and Forrester, 2002). It also alleviates the responsibility placed on any individual employee who is relied upon for the completion of a specific task within the manufacturing process. Should that employee remain absent from work, it limits the manufacturing process and renders the incomplete processes that precede the task required for completion (Karlsson and Ahlstrom, 1996). Respondents were asked if multifunctional teams exist within the organisation and if they are arranged at different manufacturing processes (Q3.5.1). It was found that there is a lack of multifunctional team members, which shows a shortage in the skill set of employees. This shortage can be problematic, as limiting the number of employees who are able to perform more than one task limits the rate at which the manufacturing process progresses and the efficiency of the manufacturing line (De Vries, 2015).

In order to improve the implementation of multifunctional teams as a viable form of employee operations, a logical and methodological strategy needs to be applied to creating multifunctional teams to work within different manufacturing cells. Karlsson and Ahlstrom (1996) found that supervisors are required in the initial stages to create a systematic flow in terms of how tasks are exchanged between employees. Thereafter, training needs to be administered to employees to ensure that they are able to efficiently perform the tasks expected of them without any form of supervision and effectively work within a team. Training ensures that the skills of any given employee involved with the manufacturing process are not stagnant as a result of performing the same task continuously. There should also be a system that allows for employees to be trained in coping with malfunctions and defective parts, should they occur. Consequently, this system eliminates the need for a secondary party to be called in to repair the part that may have malfunctioned. It should also allow for an increase in the number of members within a multifunctional team, should the tasks required for a given process be too expensive for a limited number of people to handle (Soriano-Meier and Forrester, 2002).

5.7 Decentralized Responsibilities

Decentralized responsibilities is a principle of lean manufacturing that works in accordance with the multifunctional teams' principle. This principle refers to the breakdown of supervisory tasks among members of multifunctional teams and the delineation of a hierarchical system within the work place (Hook and Stehn, 2008). The decentralization of responsibilities ensures that each member of a multifunctional team takes a turn in a supervisory role and gains the training and experience required to perform the tasks required of them (Karlsson and Ahlstrom, 1996).

Respondents were asked questions Q3.6.1 – Q3.6.5. It was found that there are no aspects of decentralized responsibilities that has been applied to the manufacturing process at Altech UEC. This shortcoming disadvantages any multi-functional teams in existence as it then means that all supervisory roles are handled by a member of management (Scott, Butler and Edwards, 2001). Respondents were asked if operators are responsible for planning, maintenance, inspection and quality to prevent the disruption of product flow (Q3.6.1). The finding reveals that it is not operators who are responsible for planning and maintenance activities within the manufacturing line. This indicates that there could be an external party involved in ensuring that the production flow is not disrupted or that there may be no one in charge of these tasks, which is a large concern for the state of the manufacturing process at Altech UEC. Chaneski (2014) found that companies who did not train and utilize employees to manage and oversee the manufacturing process faced the risk of an inconsistent level of quality in their products and manufacturing line. An external party or member of management does not have the same level of familiarity with the manufacturing process as an individual who is directly involved with the manufacturing process. This also limits the capabilities of multifunctional teams as the rotation of tasks and routine of work are all controlled by a supervisor and not decided by the team, thereby creating a hierarchy within the workplace (Scott et al., 2001).

The decentralization of responsibilities within the multifunctional teams that perform duties within the various manufacturing cells that make up the manufacturing process ensures that all employees gain experience within a supervisory role and provides them with an in-depth knowledge of what is required for the manufacturing process to flow efficiently and with minimal error (Karlsson and Ahlstrom, 1996). By limiting the responsibilities and supervisory tasks to one person within each manufacturing cell, it limits what the team within that cell is responsible for as team members are required to take instruction from that individual and limits free thinking and places a form of hierarchy within that manufacturing cell that is influenced by a number of different factors, such as nepotism or insufficient conflict resolution between employees (Hood and Stehn, 2008). The lack of decentralization of responsibilities also limits the influence that employees have within the decision making and places them in a consultancy capacity. Consequently, it demoralizes employees as this shows the lack of trust that the company has in the capabilities of its employees, which creates a tenuous relationship between management and employees and may result in a number of employees choosing to leave the company (Chaneski, 2014).

There are several challenges that face integrating the principles of decentralizing responsibilities into the manufacturing process. The first is that there could be a significant level of cost associated with attempting to train employees in the various supervisory tasks required for the functioning of a specific manufacturing cell within the manufacturing process, as the number of people that are a part of each multifunctional team may be a large number, due to the number of tasks required for each manufacturing cell to complete its portion of the manufacturing process (Scott el at., 2001). Another challenge that faces integrating decentralized responsibilities into the manufacturing process is the unwillingness of employees to undergo the required training to make this a reality as they may be comfortable with the current system and are accustomed to taking instructions from a supervisor (Karlsson and Ahlstrom, 1996). To remedy this challenge, companies can slowly integrate employees into the decisions that regard the manufacturing process and make employees accustomed to making decisions and providing an input with regards to the manufacturing process, and the part that they are familiar with and, then create a training programme that develops these skills further (Hood and Stehn, 2008).

There are drastic improvements that can be made to implementing the principle decentralization of responsibilities as part of the manufacturing process. Implementing lean manufacturing allows for the number of levels within a hierarchical system to decrease as there isn’t a singular individual responsible for a number of different supervisory duties as these duties are shared amongst members of a multifunctional team. Moreover, there is no person that assigns duties since the rotation of duties is decided amongst members of the multifunctional team (Scott et al., 2001). The decentralization of responsibilities also allows for the operators within the manufacturing process to be actively involved in the decision-making process with regard to the maintenance and production activities that are part of ensuring that the manufacturing process is run efficiently. Hook and Stehn (2001) found that allowing operators to be actively involved in supervisory tasks required for the completion of the manufacturing process encourages initiative from employees and allows them to be actively involved in attempts to further improve the manufacturing process.

5.8 Integrated Functions

Integrated principles is a part of lean manufacturing that ensures that any tasks previously done by teams of employees not directly involved with the manufacturing process can be taken over by multifunctional teams and performed by a member of that specific team when required to maintain or facilitate the efficient running of that particular manufacturing cycle (Karlsson and Ahlstrom, 1996). This includes activities that are not a direct part of the manufacturing process but are required for the completion of the manufacturing process, such as the transportation of materials or administrative work related to logging the activities linked to the manufacturing process (Mund, 2011).

Upon reviewing questions Q3.7.1 –Q3.7.6, it is clear that Altech UEC has not made use of the integrated functions principle within their manufacturing line. Respondents were asked if indirect tasks, such as materials handling, planning, maintenance and quality control, are performed by multifunctional teams (Q3.7.1). The finding reveals that employees were of the opinion that multifunctional teams should be assigned to indirect tasks as well as tasks that are a direct part of the manufacturing process. Hence, there is a reduction in the the ratio of indirect employees to direct employees. This means that multifunctional teams would be responsible for all processes involved in the manufacturing process, including indirect activities. The lack of integrated functions, as part of the manufacturing process, limits the capabilities of the multifunctional teams that are active within the manufacturing process. Toralla et al. (2012) found that, as multifunctional teams and integrated functions go hand in hand, it limits the tasks that multifunctional teams are able to complete. It also limits the level of assistance that multifunctional teams are able to provide to the manufacturing process. This also limits the decentralization of responsibilities as a member of management or a supervisor is required to direct employees involved in indirect tasks of the manufacturing process. Therefore, all functions within that specific section are halted until indirect employees are able to perform the required tasks (Mund, 2011).

The principle of integrated functions works in conjunction with multifunctional teams and decentralized responsibilities. Each principle ensures that the skills of the work force are fully utilized so that the manufacturing process is carried out in an efficient and optimized manner (Karlsson and Ahlstrom, 1996). The impact of the training that employees are then required to receive and implement as part of their tasks creates a level of efficiency with how the manufacturing line progresses. This, in turn, increases the rate of the manufacturing process (Mund, 2011). The lack of training has a negative impact on the morale and loyalty that employees have for the company in which they are employed. This means that the employees' abilities are limited and not grown within the positions they are required to fulfil. By providing training to employees and growing their skills past a singular task allows employees to become educated and experienced on various parts of the manufacturing process which, in turn, has a positive impact on the manufacturing process (Karlsson and Ahlstrom, 1996). Thus, in order for employees to feel valued by their company, the company needs to ensure that it implements programmes and training that allow for employees to perform a variety of tasks (Toralla et al., 2012).

Training is required for multifunctional teams to be able to perform a number of different tasks, including indirect tasks. Mund (2011) found that a number of different employees were reluctant to participant and complete the training provided as it proved to be too arduous or inconvenient to employees. Such reluctance presents a challenge to the implementation of integrated functions as a system for the utilization of the skill set of employees. Another dilemma is the lack of funds that often exists in terms of funding training programmes and skills workshops. A company like Altech UEC may offer training programmes that are not customized to the needs of the employees, but is based on a projection of required skills that was drawn up by management (Toralla et al., 2012). In order to rectify this challenge, it is the responsibility of management to proactively engage with employees to ascertain what they require in terms of skill programmes and training to ensure that the number of different acquired skills benefits the company and the manufacturing process (Mund, 2011). The skills acquired by employees to assist with their integrated function should also be placed within the context of the company and country to which they belong. Karlsson and Ahlstrom (1996) found that developing countries have a smaller reliance on automated processes than companies that are part of a first-world country.

For lean principles within the manufacturing process to be improved, they must first be implemented to replace the old systems and functions of the previous manufacturing process (Ndou, 2009). The first step for Altech UEC to begin implementing lean manufacturing, is for employees with the various manufacturing cells that make up the manufacturing process to undergo the necessary training to improve their existing skill set. Thereafter, teams can be begin to develop and adhere to a rotation schedule which is agreed upon by all members of that team (Toralla et al., 2012). Once this is fully functional, it is for management to arrange programmes and skills workshops in which individuals are educated on the various indirect tasks that are a part of the manufacturing process and learn how to perform them for themselves. Therefore, there will be a decrease in the number of members of indirect staff that are involved in the manufacturing process and an increase in the number of skills of an individual within the manufacturing process (Mund, 2011). Once these steps are complete, the concept of multifunctional teams should then be combined with the principle of decentralized responsibilities and integrated functions to ensure that the manufacturing process is at optimum levels of efficiency and speed (Karlsson and Ahlstrom, 1996).

5.9 Vertical Information Systems

The principle of vertical information systems enables the necessary information to be passed along to employees working on the manufacturing line through a form of communication that is accessible to all employees. Similarly, feedback is provided to managers and supervisors from employees about improvements that can be made to the manufacturing system and the materials and resources required for the manufacturing process to progress (Karlsson and Ahlstrom, 1996).

There is a degree to which the principles of vertical systems have been implemented within Altech UEC. However, there are aspects that are missing and are required for total transparency on the part of the management of the company. Respondents were asked if the organisation shares strategic information, such as organisation market plans and financial performance to all employees (Q3.8.2). The finding reveals that the company shares information on all aspects of business and on the market plans and financial performance of the company. This is an indication that the company allows for employees to be aware of the performance levels of the business so that they are aware of the current state of the business and will thus contribute to maintain or improve this level of business (Aoki, 1986). It also allows for employees to feel included in the state of the business as the information that is disseminated is also as a result of the contribution of employees to the manufacturing process, and thus has a direct effect on their morale and loyalty to the company (Bakos, 1991). The principles that are implemented work in conjunction with one another as they are both linked to the manufacturing process. This means that each employee is aware of the state of each aspect of the business and how it affects the overall state of the manufacturing process (Aoki, 1986).

Respondents were asked if the organisation shares operational information, such as productivity, timelines and quality to all employees (Q3.8.3). The finding reveals that that employees are not informed of the operational aspects that are required for the efficient functioning of the manufacturing process, such as the rate of productivity, timeliness of the manufacturing process and quality of the manufacturing process. This could have a negative impact on the relationship between the employees and the business as well as the manufacturing process as employees are a direct contributing factor to the state of these aspects, If employees are left unaware of the state of these aspects, they will be unable to improve their performance on the operational factors involved in the manufacturing process (Karlsson and Ahlstrom, 1996). The lack of information in designated areas to inform employees on anything that may require their attention can also pose a problem and have a negative impact on the degree to which lean manufacturing is able to improve the manufacturing process as it hinders the ability of employees to make informed decisions to the manufacturing process and what management thinks is required for the improvement of activities that are required for the completion of the manufacturing process (Kumar and Van Dissel, 1996). The implementation of all aspects of vertical information will improve the flow of communication between employers and employees and have a positive impact on the manufacturing process (Puvanasvaran, Megat, Hong and Razali, 2009).

Changing the communication system that exists within a company can be challenging as employees and management grow accustomed to the system that is currently in place. Thus, it is the duty of the management team and media department to slowly transition employees from the old way of communicating to the new way (Puvanasvaran et al., 2009). There are several challenges regarding implementing a vertical information system. The first is ensuring that the information is disseminated in a format that is accessible and easy to use for all employees so that the information is understood effectively and implemented (Kovacheva, 2010). Another issue would be the semiotics of sending out messages and ensuring that the context in which the message is issued is understood by employees. The context refers to the language used and the complexity of the message (Kumar and Van Dissel, 1996). Karlsson and Ahlstrom (1996) found that if the grammar or semiotics of the messages passed on from management to employees was too complex, it could confuse them and hinder their productivity as they struggled to interpret what the message meant. Thus, it is vital for employees to place messages within a context that is easily understood by employees.

The communication system at Altech UEC can be greatly improved by implementing vertical information systems as an alternative form of communication that occurs between employees and management. Kumar and Van Dissel (1996) found that the information that can be passed on to employees from management can be streamlined and should only pertain to business-related matters and not any external information that may be irrelevant to the functioning of the company as this could prove unnecessary to the manufacturing process. By allowing for the implementation of a vertical information system, it ensures that information reaches all parties involved with the manufacturing process and that all teams and employees are up-to-date on the current state of business (Puvanasvaran et al., 2009). The medium that is being used to communicate can also hinder employees and their progress. If the designated area for news and informative updates is placed within an inconvenient section of the company, it makes it difficult for employees to access. Similarly, if employees are unable to access their emails at their work stations, any communication via email can be counterproductive (Kumar and Van Dissel, 2009). Therefore, it is the duty of management to ensure that all communication to employees is done within a medium and structure that is accessible to all employees so that employees are able to implement changes and act on the information given with immediate effect and are not delayed as a result of the inaccessibility of the information (Karlsson and Ahlstrom, 1996).

5.10 Pull instead of Push

Pull is a system that is used to ensure that the stock being manufactured by a company meets the actual demand that exists for the product. Push refers to the production of goods according to the forecasted needs of the consumer, since all early processes of manufacturing generally work off of a push system and the ending processes work off of a pull system. The pull system is then implemented to ensure that the mounting processes are completed within the required time and the amount of stock produced is as close to the actual number as possible to ensure a minimal amount is put into inventory (Hopp and Spearman, 2004).

The pull instead of push system ensures that there is no excess of stock produced as a result of producing goods according to the actual demand of stock from consumers instead of the forecasted need of stock, which means that there is no backlog of work at any given work cell within the manufacturing process (Savino and Mazza, 2015). Respondents were asked if the organisation manufactures products to actual customer demand or forecast (Q3.9.2). The finding reveals that, while the company manufactures stock to meet real customer demand, there are no other aspects of the pull system that is implemented to maximise the efficiency of the manufacturing process. The implementation of ensuring that the stock manufactured meets the demand of real customer demand and not projected customer demand guarantees that there is no excess stock produced. This means that the inventory of stock is minimised, and reduces the reproduction of waste in other parts of the manufacturing, and all materials and resources are adequately used in the correct amounts (Karlsson and Ahlstrom, 1996). There are system defaults as a result of the lack of any other system that utilizes the pull principle within the manufacturing process and these could cause a backlog in the amount of work that needs to be completed (Hopp and Spearman, 2004).

The pull system impacts on the manufacturing system in a number of ways. By not providing employees with the in-depth knowledge required for the effective implementation of the pull system within the manufacturing process, it inhibits their ability to cope with backlog, should it arise, and from effectively judging when and how much of the output is required from a previous process (Hopp and Spearman, 2004). The pull system also impacts on how the amount of materials and resources are distributed as the pull system uses a kanban card system to indicate when materials are required to complete the current phase of the product being manufactured. Manufacturing companies, who do not use this system, do not have an effective form of communication for manufacturing cells that require a certain part or material. Having employees to manually fetch the part or material from where it is located hinders the manufacturing process and causes a backlog in the amount of work that still needs to be completed (Karlsson and Ahlstrom, 1996). The pull system, as a means of ensuring that there is no backlog of work, also proves to be effective as it ensures that the output from one manufacturing process is used when needed by another. Therefore, there is no wastage of materials and resources within the manufacturing process and each manufacturing cell is consistently and proactively contributing to the manufacturing process (Nenni, Giustiniano and Pirolo, 2014).

One of the challenges that face the implementation of the pull system within Altech UEC is the lack of education that has been given to employees regarding how the pull system functions and affects the manufacturing system. By not providing employees with the necessary knowledge, it restricts employees from effectively implementing the pull principle to improve the manufacturing process and limits the knowledge of employees to the push system which, in turn, hinders the progress of the manufacturing process (Savino and Mazza, 2015). Another challenge that faces the implementation of the pull system, as a system of functionality within the manufacturing system, is that regular systems of functionality require large quantity lots to ensure that there is stock in surplus should the demand be greater than anticipated. The pull system, on the other hand, of functionality requires smaller lots so that defects are easier to identify and correct before they are sold to the consumer (Karlsson and Ahlstrom, 1996). By reducing quantity lots of the product being produced, the product amount meets the demand by consumers. Inventory stock is reduced, and no stock can be counted as waste as a result of the quality of stock diminishing due to spending time in storage (Hopp and Spearman, 2004).

There are several improvements that can be made to the implementation of the pull system with the manufacturing process at Altech UEC. Firstly, there is no support for employees with regards to their knowledge on the different principles required for the successful implementation of the pull instead of push system, Nenni et al. (2014) found that employees, who received adequate training in the mechanisms of the pull instead of push system, were able to effectively change how the output system functioned and reduced the backlog of work that still needed to be completed as part of the manufacturing process. Another area that can be improved is implementing a Kanban card system to indicate when a manufacturing cell requires materials and resources to be replenished. The Kanban card systems ensures that the correct amount of materials is distributed to the correct manufacturing cell in the precise amount that is required so that there is no excess and no materials or resources are chalked up to waste due to lack of use (Karlsson and Ahlstrom, 1996). Lastly, by manufacturing goods according to the needs of the customer and not the forecasted need of stock, the lot sizes are reduced and a reduced inventory of stock is kept on hand (Hopp and Spearman, 2004).

5.11 Visual Management System

The visual management of a workplace refers to the neat and strategic organization of an employee's work area to ensure that there is no clutter or waste that will play a part in hindering the progress and rate at which an employee is able to complete his/her tasks (Mund, 2011). The visual management of a workplace works off of the 5S system which is a set of principles that ensures all aspects of a work station are accounted for and set with the principles of lean as a philosophy in mind (Naidoo, 2012).

Respondents were asked questions Q3.10.1 – Q3.10.5. The finding reveals that while the core values of visual management within a lean manufacturing context were taken into account and implemented within Altech UEC so that the work stations of employees remained in a neat and manageable condition, other aspects of visual management were applied to ensure that employees were aware of the details that were essential to their work within the manufacturing process. The implementation of graphs that are consistently updated to indicate the downtime of equipment ensures that employees do not overuse equipment which could result in a malfunction or defect, which would mean a delay while it is being repaired (Mohammadi, 2010).

Vermaak (2008) found that another way to implement visual management strategies within the context of lean manufacturing principles is graphs that indicate defects that have occurred within a specific workstation in the manufacturing process. Vermaak (2008) also found that this alerts the teams responsible for repairs within the manufacturing process of the defect and that it needs to be addressed. There is also a system of graphs that alerts employees to the current level of production so that employees are aware of whether they need to improve the rate and efficiency of their work to increase or maintain a high standard and efficient pace of manufacturing (Sanchez and Perez, 2001).

In terms of the 5S principle, the visual management of a workplace has a number of advantages and impacts positively on the manufacturing process. The 5S system stands for sort, straighten, shine, standardize and sustain, all of which contribute towards keeping the workspace of an employee neat and well maintained at any given time (Mund, 2011). Respondents were asked if they were concerned about keeping all components, tools and instruments in their place (Q3.10.1). The finding reveals that this may not have been implemented as a system used to keep all tools and components of the manufacturing process in an organized order so that the work space of employees are kept neat and in order at any given time. Another way in which it impacts on the maintenance of the visual aspects of the company is by ensuring that there is a visual system in place to update employees on the information necessary for them to carry out their job. This is one aspect that is present within Altech UEC (Mohammadi, 2010). This visualization system ensures that there is no miscommunication that can occur between manufacturing cells with regards to the state of equipment and tools or defects that have occurred during the manufacturing process and that no confusion occurs which can impact negatively on the manufacturing process (Sanchez and Perez, 2001).

The challenge that faces changing the system of visualization management that already exists is that employees have become accustomed to how the current system functions. Thus, they may be confused or unable to adapt to a new system of visualization management. The respondents were asked if their areas are clean and tidy (Q3.10.2). The finding reveals that there is a system in place to ensure that the workplace of employees are organized and neat. However employees remain in a state of dissent and disorganization. Thus, the implementation of a new system of visual management using the 5S system may prove ineffective for the same reason (Vermaak, 2008). Another challenge that faces the thorough implementation of 5S, as a system of visual management, is that there is not enough emphasis placed by companies on the importance of maintaining a clean and organized work space as it is not seen as an area of pertinence that needs to be consistently addressed and improved. This means that employees do not place the necessary emphasis on maintaining their workspace since they do not use the 5 S principles to ensure a consistent standard of work (Naidoo, 2012).

The first and most glaring improvement that can be made to the implementation of lean visualization management techniques is implementing the 5S principle to improve the neatness and organization of the work space and other components within the manufacturing process. The first principle, sort, relates to going through the various materials and tools within the manufacturing process and deciding what is necessary. The second principle, set-in-order, refers to the organization of tools and materials in a logical and systematic order. Each tool and material are chosen according to the place it is needed within the manufacturing process (Vermaak, 2008). The third principle, shine, ensures that all materials and tools required for the manufacturing process are always kept in working order and all defects are addressed and consistently monitored. The fourth principle, standardize, relates to the cleaning and maintenance routines that are internalized and become a part of the daily routine of any given employee (Naidoo, 2012). The last principle, sustain, ensures that these practices are maintained and improved, wherever possible, so that the manufacturing process runs at its optimum efficiency (Mund, 2011).

5.12 Principles of SMED (Single-Minute Exchange-Die)

This principle of lean manufacturing refers to the continuous improvement made to reducing the time required for the change of equipment to occur in which equipment being used in one part of the manufacturing process within a manufacturing cell is quickly and efficiently changed with another piece of equipment without any wastage of time in the process involved (Cumbo et al., 2006).

Respondents were asked questions Q3.11.1 – Q3.11.4. The finding indicates that there has not been a great deal of emphasis placed on SMED time reduction processes by Altech. Therefore, the time taken to complete the overall manufacturing process per cycle of production is longer than necessary and that there are a large number of areas that need to be improved (Mund, 2011). While an effort is made by employees to ensure that there is a reduction on the time spent in changeovers during the manufacturing process, there is little input by management to reduce time. By attempting to reduce the time spent for changing over equipment, it shows that employees are aware of the importance that the changeover process plays in ensuring that the manufacturing process is optimised as far as possible so that more cycles are able to occur within a day of manufacturing (Mokhalimitso, 2011). The changeover process are still hindered, however, by a number of different technical aspects that employees are not able to control and by the lack of attention given to the changeover process by supervisors and members of management. Moreover, there is a lack of employees' experience hinders the improvement of changeover times (Trovinger and Bohn, 2005).

The introduction of a SMED system used for the changeover of equipment could impact on the manufacturing process positively. The use of SMED in a manufacturing process ensures that a concerted effort towards the improvement of changeover times is made by both employees and management to approve and commission changes that need to be made to the changeover process (Cumbo et al., 2006). Employees also require training and courses on the changeover process and are able to gain practical experience during the training process to ensure that they are able to implement effective changes and reduce the time independently, without the assistance of management, which the streamlines the improvement process (Rymaszewskai, 2014). Another practice that can have a positive impact on the changeover time of equipment during the manufacturing process is ensuring that the machinery required for the next part of the manufacturing process within any given manufacturing cell is prepped and is in a functional state and ready for use. Consequently, there is no delay to the manufacturing process and the changeover time between equipment is further reduced to allow for an efficient and fast rate of changeover (Mund, 2011).

One of the challenges that faces implementing the SMED system, as an active equipment changeover system, is attempting to recondition employees to using the SMED system and reducing their use of the previously used system. This will need to be done with the implementation of all employees who are a part of a manufacturing cell or directly involved with the manufacturing process (Mokhalimitso, 2011). The management at Altech UEC needs to acknowledge the significance of implementing an effective changeover system. Respondents were asked questions Q3.11.1 and Q3.11.2. The finding indicates that employees did not place importance on the reduction of time in the equipment changeover process. Management needs to meet with employees on a monthly or weekly basis and discuss the ways in which the reduction of time in the changeover over process are being increased. Management should suggest ways in which employees can improve on this reduction. Supervisors can also receive training on how to effectively implement SMED as part of the manufacturing process and then implement these changes to the manufacturing process at Altech UEC (Trovinger and Bohn, 2005). Many companies do not allow for the consistent maintenance of machinery and equipment to ensure that it is always functional and ready for use. It is the duty of the company to ensure that this maintenance is allowed as it improves on the changeover time within the manufacturing process (Mund, 2011).

One of the improvements that needs to happen within the equipment changeover process at Altech UEC is the implementation of a training programme to assist employees with gaining practical knowledge and experience with various aspects of the manufacturing process. The respondents were asked if workers are trained to make quick batch changes and they practise to reduce the time they invest in the task (Q3.11.2). The finding shows that there was a lack of training and development programmes for employees to improve their current skills and gain knowledge of the manufacturing process (Rymaszewska, 2014). Another way in which the equipment changeover process can be improved is implementing a system that ensures the equipment and machinery that are required for each process within a particular manufacturing cell is kept ready and in a usable condition so that there is no delay in the manufacturing process and no wait period as certain equipment or machinery may require a warm-up period or a manual input before use (Mund, 2011). Trovinger and Bohn (2005) found that, if companies are able to implement a system so that machinery is already warmed up and assembled for use, it provides a significant reduction in the amount of time needed to complete a specific process. Hence, companies have to take the initiative and utilise SMED processes to their full potential to ensure that is able to effectively assist the manufacturing process.

5.13 Supplier Relations

Supplier relations within the context of lean manufacturing refers to improving existing relations by negotiating costs and prices of materials and resources that benefit both the supplier and the company and ensures that no amount of excessive stock is purchased from the supplier and choosing a supplier with the highest quality of materials (Duiker, 2014).

Lean, as a concept for handling matters of business, also includes how supplier relations are handled by the company. Altech UEC applies several aspects of lean manufacturing to the relations that exist with existing and potential suppliers. These aspects are illustrated by the responses to questions Q3.12.1 –Q3.12.5. Respondents were asked if there is a clear strategy in place to evaluate supplier performance in terms of quality, delivery and price (Q3.12.1). The finding shows that there is a clear strategy in existence to cope with the evaluation and selection of suppliers. There is also a criterion that needs to be met in order for a company to be listed as a supplier by the company. This shows a stringent selection process which ensures that the quality of resources used by the company is of the best quality so that the overall product is of the best quality (MacDuffie and Helper, 1997). The company has also implemented a system with existing suppliers to enable all stock ordered to arrive within a specific time frame after it has been purchased. This system of delivery ensures that there is no delay to the manufacturing process as a result of waiting for materials (Duiker, 2014). The use of lean manufacturing principles in supplier relations provides regular feedback to suppliers with regards to the stock being purchased. Therefore, suppliers and the company are consistently interacting to improve the quality of materials being purchased (MacDuffie and Helper, 1997).

The inclusion of lean manufacturing principles into all aspects of business has a positive impact on the business as a whole. Applying lean manufacturing principles to supplier relations ensures that all goods are received timeously and are of the highest quality (MacDuffie and Helper, 1997). While the parts and materials needed by Altech UEC are not sourced locally, the production time remains unaffected due to a rigid delivery schedule and consistent checks and inspections by the company to ensure a consistency in the quality and delivery time of the supplies that are ordered (Duiker, 2014). The use of lean principles, as a mechanism for negotiating with suppliers, also ensures that there is no wastage in terms of an excessive amount of stock being delivered to the company. This means that stock is ordered according to the amount that is required and is entirely used within the manufacturing process once it has arrived. Therefore, materials do not lose their level of quality by being placed in inventory, and the quality of the end product is not compromised (Duiker, 2014).

Like any other aspect of a business, there are challenges when attempting to apply lean principles to how supplier relations are handled by the business. The first challenge would be attempt to renegotiate and changing existing relations with suppliers and negotiate deals that are in line with the lean manufacturing ideals of the business. It would first require explaining the shift in the manufacturing process and the resulting need to shift how business is conducted with suppliers to compensate for these changes (MacDuffie and Helper, 1997). Another challenge would be to include local suppliers as part of the supplier list, as larger manufacturing companies like Altech UEC usually outsource their supply needs to foreign suppliers, which increases price and delivery time. Naidoo (2012) found that the materials received from local suppliers can be of equally consistent quality as their foreign counterparts. Thus, the company should take the initiative to engage with local suppliers and negotiate a business deal that is beneficial to both parties and assist in the growth of the local economy (Duiker, 2014). Finally, it is the duty of the company to ensure that all raw materials ordered and purchased are of the required quality and match the needs of the manufacturing process. A challenge in this regard is a lack of involvement by management in the inspection process. The responses to question Q3.12.5 indicate that raw materials and purchased parts are not subject to incoming inspection. The responses confirmed that employees conduct inspections of raw materials (Mund, 2011).

While lean manufacturing principles have been sufficiently integrated into how supplier relations are managed, there are still several areas of improvement. Firstly, there needs to be more negotiation and interest in local suppliers rather than relying on foreign suppliers for raw materials and resources. Such negotiation increases the local economy and strengthens relations with the community in which the company is based (Duiker, 2014). The company can also assist the supplier with attempting to integrate more principles of lean manufacturing into how business is done so that there is minimal waste in the form of excessive stock.

Moreover, the time taken to deliver raw material stock is constantly being improved to ensure that the manufacturing cycle is receiving the required materials to be completed quicker (MacDuffie and Helper, 1997). Lastly, if a member of management is also a part of the inspection process, t there is a very small or non-existent margin for error. Hence, there is a consistency in the quality of the goods that are delivered (Duiker, 2014).

5.14 Customer Relations

Applying lean manufacturing principles to how customers are treated by the company means that queries made by customers are handled promptly and efficiently and fulfil the needs of the customer without the addition of any unnecessary services or charges (Taj, 2008). The use of lean principles also means that the customers are allowed to be proactively involved in the manufacturing process and provides feedback on the number of different aspects of the product that they purchased (Escobar and Revilla, 2005).

Respondents were asked questions Q3.13.1- Q13.13.4. The findings reveal that lean principles have been thoroughly implemented when it comes to the type of relationship between customers and employees. Employees at Altech UEC have a close working relationship with their customers. There is frequent contact with regular customers and a consistent effort is made to enable customers to play a proactive role in the manufacturing process. Goeldnerand and Powell (2011) found that customers, who make visits to plants and are in direct contact with the manufacturing process, are able to provide in-depth and refreshing insight into improvements that can be made to the manufacturing process as a whole. Surveying and contacting customers on the different requirements of the end product allows the company to gauge what is popular and necessary within the end product. This exercise provides valuable knowledge on how the product can be improved and redesigned to match the needs of the consumer target audience (Taj, 2008).

The use of lean manufacturing in establishing a stable and productive relationship with customers impacts positively on the manufacturing process as a whole. Womack and Jones (2003) found that allowing customers to provide feedback on the quality of the product allows for practical improvements to be made to the end product. Thereafter, adjustments are made to different processes within the manufacturing line, which improves the quality of the manufacturing process as a whole. This is also linked to the feedback that customers are able to provide to the quality of the product and acts as a consensus on how well the product is made. Customers can also determine if there are any improvements that can be made and, if so, where (Sarkar, 2007). Respondents were asked if customers provide Altech UEC with feedback on product quality, delivery and timing (Q3.13.4). The finding reveals that the feedback provided by customers also impacts on the times that the product is delivered to the customer. Therefore, wastage in the form of time is minimized as far as possible as the goods are delivered within a specific amount of time so that customers are able to rely on the time in which the goods that they have ordered are received (Taj, 2008).

There are challenges to changing the dynamics of a customer and employee relationship to better suit the needs of a lean manufacturing company. While Altech UEC has been able to effectively integrate lean manufacturing principles into the working relationship shared with customers, there were several aspects that needed to be adapted in order for the transition to lean manufacturing principles to be successful and, if done incorrectly, can prove to be detrimental to the integration process. The first was changing the protocols and processes pertaining to the purchasing of goods by the customer. Sarkar (2007) found that any kind of change to a system that customers have become used to purchase the required goods can be confusing and often results in the loss of business to the company, if it is not properly explained and introduced to the customer. Another problem that can be encountered when changing the dynamics of customer relations is asking customers to become proactively involved with the manufacturing process. Most customers are not used to providing an opinion on the goods that they receive and may also lack the necessary experience or critical skills to make an informed decision on the quality of the goods that they are purchasing. Thus, the feedback received from customers could be counterproductive to the manufacturing process (Taj, 2008).

Since Altech UEC has managed to successfully integrate lean manufacturing into the relationship that is shared with customers, there are no areas that need to be improved. The relationship between the customer base and the company is in good standing. This is noticeable from the responses to questions Q3.13.1- Q3.13.4. The findings show that there is a mutual understanding between the customer and the company in terms of the feedback that is received and the consistent involvement of the company with the manufacturing process (Womack and Jones, 2003). The only way in which this area of lean manufacturing principles could be improved would be to provide an interactive feedback system that allows employees to address the feedback provided by customers immediately (Taj, 2008).

5.15 Knowledge Management

According to Dumbrowski and Engel (2012), knowledge management within a company refers to the broad area of all practical experience, demonstrable knowledge and training and development of skills that have occurred across any given work force and management and is exchanged and taught according to the needs presented by the manufacturing process. Within lean manufacturing, all information that is gained offers a level of benefit to the manufacturing process and assists in the removal of waste from the manufacturing process (Skogmalm, 2015).

Despite a fairly extensive integration of lean manufacturing principles into other aspects of business, the management of knowledge within Altech UEC seems to have been overlooked. The responses to questions Q3.14.1 – Q3.14.4 indicate that no aspect of knowledge management under the lean philosophy has been implemented. Therefore, there is no effective system in place that encourages the innovation of knowledge on the part of employees (Mund, 2011). Respondents were asked if the company has regulations supporting innovative ideas, research and exploitation (Q3.14.1). The finding indicates that there is no regulation that supports initiatives made by employees in their attempt to improve the manufacturing process. All ideas linked to research and exploring alternative avenues to the current manufacturing process are neglected and not nurtured by management, which can be detrimental. Skogmalm (2015) found that companies that do not have an area or department which focuses on the research and ideas of employees often tend to stagnate. The lack of change in the manufacturing process often affects the quality of the product detrimentally as there is no improvement to the quality or function of the product which, in turn, leads to a lack of interest from customers and a loss of profit to the company.

The management of knowledge can impact greatly on the manufacturing process in a number of different ways. The lack of knowledge and database systems that allow for the dissemination of information across the company disadvantages employees as there is nowhere for them to disseminate or share any new information with colleagues that may improve that particular area within the manufacturing process (Dumbrowski and Engel, 2012). Another way in which it impacts upon the manufacturing process is that it allows for the continuous growth in the knowledge base and updates. The experiences of employees and management increase, thereby allowing for a more in-depth and extensive understanding of how the manufacturing process functions and what is required to improve on existing structures and processes within the company (Puvanasvaran et al., 2009). The management of knowledge within a lean context also allows for the dissemination of information to other branches and sister-companies which, in turn, allows for the expansion of the information that was originally disseminated. This means that the knowledge base within a company is permanently in a state of growth (Skogmalm, 2015).

The gathering of knowledge from all employees within any given company can be challenging. Therefore, Altech is unable to implement an effective knowledge management strategy. There may also not be a budget available within the company to support the creation and management of a knowledge database. Dumbrowski and Engel (2012) found that companies are unwilling to compromise on any adjustments to their budgets to make funds available for any kind of knowledge enhancement. This means that employees are most disadvantaged as they are not provided with the resources necessary to enhance their existing knowledge of the manufacturing process. Hence, they will lack the skills and capacity required to improve. Another challenge may also be the lack of emphasis that is placed on the enhancement and growth of knowledge within a company. Therefore, employees are left without an understanding of how pertinent the role of knowledge plays within their daily tasks as it allows for the improvement of employees' job performances, and makes the process of completing the manufacture of the produce more efficient and quicker (Puvanasvaran et al., 2009).

Improvements to this area of the manufacturing process involves total employee and management participation. The growth and initiation of a knowledge base requires input from all parties involved with the manufacturing process. In the context of lean manufacturing, input is required in the form of knowledge of the manufacturing process, improving the functionality of the company to better minimize the waste within a company, and improve upon the times and rates at which processes and tasks are completed. There are formal mechanisms that can be put into place to ensure that all information is made available to employees at Altech UEC. Dumbrowski and Engel (2012) found that including a protocol that can be used for the access and input of knowledge gives employees the opportunity to share information that they think may be valuable to the manufacturing process. Having a designated area to the sharing of knowledge also helps as it gives employees an area in which they are able to focus on what to learn rather than have to worry about a number of different tasks at once (Skogmalm, 2015).

5. 16 Recommendations for Future Research

Research into lean manufacturing within a South African context is still relatively unexplored. While there are a number of studies done into lean practices already being implemented; the introduction of lean manufacturing into a company is still relatively unexplored.

To ensure that the data are entirely objective and not influenced by the individual carrying out the study, a third and objective party should be hired to carry out the data collection process.

This research and most research exploring lean manufacturing generally takes a quantitative approach to the research. Future research could take a qualitative approach and conduct focus groups or face-to-face interviews to get a narrative analysis of the perceptions employees and management have of lean manufacturing.

While all questionnaires were answered, it is recommended that future research into lean manufacturing should administer a shorter questionnaire to ensure the retention of attention from participants.

While lean manufacturing is well established abroad, it is recommended that future research look at companies that have assisted with establishing lean manufacturing in South Africa as a point of interest.

5.17 Limitations of Study

There are a few limitations that could have an influence on this study:

i. Data collection. This was by means of a questionnaire that was completed by employees of the organisation. This was a closed-response questionnaire with no control on the response rate;
ii. Respondents might not have given their honest feedback due to victimisation, although anonymity was guaranteed;
iii. The details of the study were explained to all respondents but they could be of the opinion that the feedback will not influence outcomes; and

iv. The questionnaire did not look at the respondents’ length of service in the organisation. This could have an impact as respondents who were new would not understand the questions.

5.18 Recommendations

The first research question looked at the methods and principles of lean manufacturing that was implemented. Each section of the questionnaire covered a particular area of interest under the lean manufacturing principles covered by Karlsson and Ahlstrom (1996), which provided a clear understanding of the principles and methods being implemented within Altech UEC. The results throughout each section showed that, while there were attempts to implement certain lean manufacturing strategies, very little was being done to improve different aspects of the manufacturing process. The majority of the decisions made regarding the manufacturing process were made by management with very little or no input from employees. Employees were also not provided with the required training and were not given any kind of initiative to assist in improving how various processes were being carried out.

The second research question looked at how lean manufacturing principles were able to impact on the manufacturing process as a whole. The results showed that, as a result of the lack of implementation of the core areas of lean manufacturing, lean manufacturing did not have too much of an impact on the manufacturing process at Altech UEC. The very few aspects of lean principles that were implemented in the manufacturing process at Altech UEC lacked the necessary support structure that is provided by other aspects of lean manufacturing to become a permanent change within the manufacturing process. This requires further development to be able to have a greater impact on the manufacturing process.

The third research question looked at what challenges face the implementation of lean manufacturing within the company and the different aspects that present a challenge and deter the implementation of lean manufacturing principles as part of the lean manufacturing process. The results found that there were several contextual challenges that faced implementing lean manufacturing within Altech UEC, such as a lack of funding for the implementation of new systems, and a lack of a knowledge base from which employees could learn. There was also a challenge posed by management who did not include employees in decisions that affected the manufacturing processes, thereby excluding the experience employees in the manufacturing process.

The fourth and final research question examined what could be done to improve on the implementation of lean manufacturing within Altech UEC. The results collected and analysed found that there were drastic improvements that could be made to the manufacturing process. Reviewing the results of each section within the questionnaire showed that there were necessary improvements that needed to be made to the removal and reduction of waste within the manufacturing process. This could be done in each section of the company to ensure that the manufacturing process runs as efficiently, and to reduce waste by removing all unnecessary materials and processes from the manufacturing line. Another way in which it could be improved would be to provide the adequate training required to place employees into multifunctional teams to ensure all skills accumulated by workers were being fully applied towards the completion of the manufacturing process.

The study was able to effectively conclude that lean manufacturing impacts positively on the manufacturing process and, if implemented correctly, the manufacturing process will run smoothly and efficiently. The more lean manufacturing aspects applied to the manufacturing process, the more likely it was to run smoothly and efficiently at an increased rate of production. Thus, in order for Altech UEC to fully utilise lean manufacturing and the different principles of lean manufacturing, it needs to:

i. first implement a structure that supports the implementation of lean manufacturing as a permanent system instead of a once-off solution;
ii. involve employees in decision making;
iii. provide training to all employees on lean manufacturing tools and techniques; and
iv. create multifunctional teams.

5.19 Conclusion

This study sought to explore the use and implementation of lean manufacturing principles at Altech UEC as the basis for understanding how lean manufacturing can benefit a company within a South African context. There were four research questions asked under the broader topic of lean manufacturing. Through extensive research of previous literature and logical inferences made from the analysis of the data, it was found that, while some aspects of lean manufacturing principles were being used to improve the lean manufacturing process, there was still a great deal of improvement that needed to happen for Altech UEC to be a lean manufacturing company.

This chapter looked at the results for each section of the questionnaire and placed it within the context of the research questions that were the reason for the study. The chapter discussed the results achieved within the context of the research question being discussed and then used previous literature to support and explain the results that were achieved and also used it to recommend ways in which the implementation of lean manufacturing within the company can be improved.

Bibliography

Aalbregtse, R. J., Hejka, J. A. & Mcneley, P. K., 1991. TQM: How do you do it?. *Automation*, August, pp. 30-32.

Abdullah, F., 2003. *Lean manufacturing tools and techniques in the process industry with a focus on steel.* s.l.:PhD, University of Pittsburgh.

Abushaan, M. S., 2012. *An empirical study for Gaza Strip manufacturing firms.* s.l.:MBA,The Islamic University of Gaza.

Achanga, P., Shehab, E., Roy, R. & Nelder, G., 2006. Critical success factors for lean implementations within SME's. *Journal of Manufacturing Technology Management,* 17(4), pp. 460-471.

Allen, E. & Seaman, C., 2007. Likert scales and data analyses. *Quality Progress,* 40(7), pp. 64-65.

Alles, M., Datar, S. & Lambert, R., 1995. Moral hazard and management control in Just in time settings. *Journal of Accounting Research,* Volume 33, pp. 177-204.

Altron, 2015. *Company Overview- Milestones.* [Online]
Available at: http://www.altech-multimedia.com/company-overview/milestones
[Accessed 18 11 2015].

Altron, 2015. *Integrated Annual Report, 1 March 2014-28 February 2015,Johannesburg.* [Online]
Available at: http://altech.fin.ltc.co.za/altron/iar2015/performance/human-capital.asp
[Accessed 18 11 2015].

Alukal, G., 2006. "Lean Manufacturing". *Journal of Quality Press,* 39(4), pp. 87-88.

Anderson, S., 2007. *Implement lean production in small companies.* s.l.:MSc, Chalmers University of Technology.

Anon., 2017. *IBM.* [Online]
Available at:
https://www.ibm.com/support/knowledgecenter/SSLVMB_sub/spss/tutorials/fac_telco_kmo_01.html
[Accessed 02 05 2017].

Ansari, A., Nd. [Online]
Available at:
http://memberfiles.freewebs.com/82/66/45306682/documents/A%20Short%20Book%20on%20LEAN%20UNDERSTANDING-Ansari.pdf
[Accessed 01 12 2016].

Anvari, A. et al., 2011. A proposed dynamic model for lean road map. *African Journal of Business Management,* 5(16), pp. 6727-6737.

Aoki, M., 1986. Horizontal versus vertical informationstructure of the firm. *The American Economic Review,* 76(5), pp. 971-983.

Arif-Uz-Zaman, 2013. A methodology for effective implementation of lean strategies and its performance evaluation in manufacturing organizations. *Business Process Management Journal,* 19(1), pp. 169-196.

Arif-Uz-Zaman, S., 2013. A methodology for effective implementation of lean strategies and its performance evaluation in manufacturing organizations. *Business Process Management Journal,* 19(1), pp. 169-196.

Arnheiter, E. & Maleyeff, J., 2005. Research and concepts: The integration of lean management and six sigma. *The TQM Magazine,* 17(1), pp. 5-18.

Arsuaga Berrueta, M. et al., 2012. Instrumentation and control methodology for zero defect manufacturing in boring operations. *23rd DAAAM International Symposium on Intelligent Manufacturing and Automation,* Volume 1, pp. 385-388.

Babbie, E. J. & Mouton, J., 2001. *The practice of social research.* Cape Town: Oxford University Press.

Bakos, J. Y., 1991. A strategic analysis of electronic marketplace. *MIS Quarterly-Special issue on strategic use of information systems,* 15(3), pp. 295-310.

Bayo-Moriones, A., Bello-Pintado, A. & Merino-Diaz-de-Cerio, J., 2008. The role of organizational context and infrastructure practise in JIT implementation. *Intrnational Journal of Operations and Production Management,* 28(11), pp. 1042-1066.

Bhamu, J. & Sangwan, K. S., 2014. Lean Manufacturing: literature review and research issues. *International Journal of Operations & Production Management,* 34(7), pp. 876-940.

Bhasim, S. & Burcher, P., 2006. Lean viewed as a philosophy. *Journal of Manufacturing Technology Management,* 17(1), pp. 56-72.

Biacauna, G., 2009. *South African Institute of International Affairs.* [Online]
Available at: http://www.saiia.org.za/opinion-analysis/sas-clothing-and-textile-sector-post-chinese-quotas
[Accessed 16 11 2015].

Black, J. & Hunter, S., 2003. *Lean manufacturing systems and cell designs.* Michigan, Dearborn.

Bromley, D. B., 1990. Academic contributions to psychological counselling: I.A philosophy of science for the study of individual cases. *Counselling Psychology Quarterly,* 3(3), pp. 299-307.

Brox, J. & Fader, C., 2002. The set of just in time management strategies: an assessment of their impact on plant level productivity and input factor substituitability using variable cost function estimates. *International Journal of Production Research,* 40(12), pp. 2705-2720.

Chaneski, W., 2014. Continuous improvement is vital for remaining competitive.Committing to it across the organization is equally important. *Moden Machine Shop,* pp. 41-42.

Chen, Z. & Tan, K., 2013. The impact of organization ownership structure on JIT implementation and production operations performance. *Internation Journal of Operations and Production Management,* 33(9), pp. 1202-1229.

Cochran, P., Evershan, W., Kubin, G. & Sesterhenn, M., 2000. The aplication of axiomatic design and lean management principles in the scope of production system segmentation. *International Journal of Production Research,* 38(6), pp. 1377-1396.

Creswell, J. W., 2005. *Educational Research: Planning, conducting and evaluating Quantitative and Qualitative Research.* New Jersey: Pearson/ Merill Prentice Hall.

Cumbo, D., Kline, D. & Bumgardner, M., 2006. Benchmarking performance measurement and lean manufacturing in the rough mill. *Forest Products Journal,* 56(6), pp. 25-30.

Cwiklicki, M., 2016. Understanding management concepts through development of their tool box: The case of total quality management. *Our Economy,* 62(1), pp. 56-62.

David, J., 2008. *What are the critical success factors for lean and/or six sigma implementation in South African banks.* s.l.:MBA, University of South Africa.

DeVries, H., 2015. *The influence of lean thinking on discreet manufacturing organizational structure and behaviour.* s.l.:PhD, University of South Africa.

Domingo, T., 2013. *The adoption of lean techniques to optimise the on-shelf availability of products and drive business performance in the food industry: a South african manufacturing retail case study.* s.l.:Mcom, University of South Africa.

Douglas, J., Anthony, J. & Douglas, A., 2015. Waste identification and elimination in HEIS: The role of lean thinking. *International Journal of Quality and Reliability Management,* 32(9), pp. 970-981.

Duiker, K., 2014. *A framework for the successful implementation of lean six sigma in the capital equipment manufacturing environment.* s.l.:MBA, University of Pretoria.

Dumbrowski, U., Mielke, T. & Engel, C., 2012. Knowledge management in lean production systems. *Procedia CIRP,* Volume 3, pp. 436-441.

Emanuel, E. J., Wendler, D. & Grady, C., 2000. What Makes Clinical Research Ethical?. *JAMA,* 283(20), pp. 2701-2711.

Escobar, D. & Revilla, E., 2005. The Customer Service Process: The Lean Thinking Perspective. *Instituto de Empresa Business Working Paper,* pp. 5-13.

Ferdousi, F. & Ahmed, A., 2009. An investigation of manufacturing performance improvement though lean production: A study on Bangladeshi garment firms. *International Journal of Business and Management,* 4(9), pp. 106-116.

Forza, C., 1996. Work organization in lean production and traditional plants: What are the differences?. *International Journal of Operations and Production Management,* 16(2), pp. 42-62.

Frederick, J. G. & Larry, B. W., 2012. *Statistics for the behavioral science.* 9 ed. California: Jon-David Hague.

Fricke, C., 2010. *Lean management awareness implementation status and need for implementation support in Virginia's wood industry.* s.l.:MSc, The Virginia Polytechnic and State University.

Fujimoto, T., 2012. The evolution of production systems: Exploring the source of Toyota's competitiveness. *Annals of Busines Administrative Science,* Volume 11, pp. 25-44.

Ganguly, K. K., Dash, S. & Bandyopadhyay, P. K., 2013. Compressed New product development cycle & its impact on outsourcing decisions in auto component industry. *International Journal of Managing Value and Supply Chains,* 4(2), pp. 25-37.

Garvin, D. A., 1984. "What Does 'Product Quality' Really Mean?",. *Sloan Management Review,* 26(1), pp. 25-43.

Garvin, D. A., 1984. "What does product quality really mean?",. *Sloan Management Review,* pp. 25-43.

George, M. L., 2003. *Lean Six Sigma for Service.* New York: McGraw Hill.

Goeldner, T. & Powell, D., 2011. The use of information technology in lean production: Results of a transnational survey. *MITIP,* pp. 1-11.

Green, B. N., Johnson, C. D. & Adams, A., 2006. Writing narrative literature reviews for peer-reviewed journals: secret of the trade. *Journal of Chiropractic Medicine,* 5(3), pp. 101-117.

Guba, E., 1990. *"The alternative paradigm dialog',.* E.Guba (ed.) ed. The Paradigm Dialog, Newbury Park, CA: Sage.

Hague, P., 2002. *Market research: a guide to planning, methodology and evaluation.* 3rd ed. London: Kogan Page.

Hakes, C., 1991. *Total Quality Management: The Key to Business Improvement.* London: Chapman and Hall.

Hartle, H., 2012. *Development of a lean implementation strategy in a South African dependency on international automotive supplier.* s.l.:PhD, University of Cape Town.

Hefer, P. D. W., 2009. *Implementing Lean Principles and defining the requirement for a bar code system at British Aerospace Land Systems SA.* Pretoria: University of Pretoria.

Hook, M. & Stehn, L., 2008. Lean principles in industrialized housing production: The need for cultural change. *Construction Journal,* 4(1), pp. 20-33.

Hopp, W. & Spearman, M., 2004. To pull or not to pull: Wht is the question?. *Manufacturing and Service Operations Management,* 6(2), pp. 133-148.

Isaacs, D., 2012. *The Barriers to Lean Implementation in High Mix, Low Volume Manufacturing- A Marine Diving Engineering Case Study.* Cape Town: University of Cape Town.

Jablonski, J., 1992. *Implementing TQM; Competing in the Nineties through Total Quality Management.* 2nd ed. San Diego: Pfeiffer.

Johns, R., Crute, V. & Graves, A., 2002. *Lean Supply: Cost Reduction or Waste Reduction?.* Bath: University of Bath.

Jozaffe, L., 2006. *Implementing lean manufacturing to improve production efficiency in the manufacturing operations at te Aspen general facility.* s.l.:MBA, Nelson Mandela Metropolitan University.

Kahlen, F.-J., Flumerfelt, S. & Siriban-Manalang, A. B., 2012. "Are agile and lean manufacturing systems employing sustainability, complexity and organizational learning?". *The Learning Organization,* 19(3), pp. 238-247.

Kannan, V. R. & Tan, K. C., 2005. Just-in-Time, Total Quality Management, and Supply Chain Management: Understanding Their Linkages and Impact on Business Performance. *The International Journal of Management Science,* Omega,33(2), pp. 153-162.

Karim, A. & Zaman, K. A.-U., 2013. A methodology for effective implementation of lean strategies and its performance evaluation in manufacturing organizations. *Business Process Management Journal,* 19(1), pp. 169-196.

Karlsson, C. & Ahlstrom, P., 1996. Assessing changes towards lean production. *International Journal of operations & production Management,* 16(2), pp. 24-41.

Kim, T., 1985. Just-in-Time Manufacturing System: A periodic Pull system. *International Journal of Production Research,* 23(3), pp. 553-562.

Kothari, C. R., 2010. *Research Methodology.* 2nd ed. New Delhi: New Age International Limited Publishers.

Kovacheva, A., 2010. *Challenges in Lean Implementation: successful transformation toward the lean enterprises. Master Thesis.* Denmark: University of Aarhus.

Kramer, B., 2014. *TT100.* [Online]
Available at: http://www.tt100.co.za/tt100_new/large-business/
[Accessed 18 11 2015].

Kuhn, T. S., 1962. *The structure of Scientific Revolutions.* 2nd ed. s.l.:University of Chicago Press.

Kumar, K. & Van Dissel, H. G., 1996. Sustainable Collaboration: Managing Conflict and Cooperation in Interorganizational Systems. *MIS Quaterly,* 20(3), pp. 279-300.

Labaree, R. V., 2009. *Research Guides: Organizing Your Social Sciences Research Paper: The Research Problem/Question.* [Online]
Available at: http://libguides.usc.edu/writingguide/quantitative
[Accessed 20 October 2016].

Leedy, P. D. & Ormrod, J. E., 2005. *Practical research:planning and design.* 8th ed. New Jersey: Prentice Hall.

Lee, J. & Peccei, R., 2008. Lean production and quality commitment – A comparative study of two Korean auto firms. *Personnel Review,* 37(1), pp. 5-25.

Lee-Mortimer, A., 2008. A continuing journey: An electronic manufacturer's perception of kanban. *Assembly Automation,* 28(2), pp. 103-112.

Liker, J. K., 2004. *The Toyota Way: 14 Management principles from the World's Greatest Manufacturer.* New York: McGraw Hill.

Liker, J. K. & Wu, Y. C., 2000. Japanese automakers, US suppliers and supply chain superiority. *Sloan Management Review,* 42(1), pp. 81-93.

Lila, B., 2012. A survey on the implementation of the lean manufacturing system in Automotive manufacturers in the Eastern region of Thailand. *In 2012, 2nd International Conference Industrial Technology and Management,* 49, Singapore, 2012.(Singapore: IACSIT).

Macduffie, J. P. & Helper, S., 1997. Creating Lean Suppliers:Diffusing Lean Production Through the Supply Chain. *California Management Review,* 39(4), pp. 118-151.

Makhomu, J. K., 2012. *Lean Manufacturing Implementation: A perspective on key success factors.* Durban: University of KwaZulu Natal.

Malterud, K., 2001. Qualittative research: standards, challenges and guidelines. *The Lancet,358*, pp. 483-488.

Manville, G., Greatbanks, R., Krishnasamy, R. & Parker, D., 2012. Critical success factors for lean six sigma programmes: A view from middle management. *International Journal of Quality and Reliability Management,* 29(1), pp. 7-20.

Marin-Garcia, J. A. & Carneiro, P., 2010. Questionaire validation to measure the application degree of alternative tools to mass production. *International Journal of Management Science,* 5(4), pp. 268-277.

Marnewick, J., 2011. *Implementing lean manufacturing and six sigma in a manufacturing environment.* s.l.:MBA, North-West University.

Marudhamuthu, R. & Krishnaswamy, M., 2011. The Development of Green Environment through Lean Implementation in a Grament Industry. *ARPN Journal of Engineering and Applied Science,* 6(9), pp. 104-111.

Mclachlin, R., 1997. Management initiatives and just in time manufacturing. *Journal of Operations Management,* 15(4), pp. 271-292.

Mcleod, S. A., 2013. *What is validity?.* [Online]
Available at: http://www.simplypsychology.org/validity.html
[Accessed 21 October 2016].

Merriam, S. B., 2009. *Qualitative Research: a guide to Design and Implementation.* 3rd ed. San Francisco, CA: Jossey-Bass.

Moen, R. & Norman, C., 2006. *Evolution of the PDCA cycle.* Chicago, s.n.

Mohammadi, A., 2010. *Lean product development: Performance measurement system..* s.l.:MSc. University of Gothenberg.

Mokhalimetso, L., 2011. *Investigating the effects of lean thinking on production processes within SMME's.* s.l.:Mtech, Cape Peninsula University of Technology.

Monden, Y., 2011. *Toyota Production System-An intergrated Approach to Just in Time.* 4th ed. London: Productivity Press.

Monette, D. R., Sullivan, T. J. & Dejong, C. R., 2011. *Appied social research: a tool for the human services.* New York: Brooke/Cole Cengage Learning.

Moore, R., 2006. *Selecting the right manufacturing improvement.* s.l.:California: Elsevier Science and Technology Books.

Morgan, G. A., Leach, N. L., Gloeckner, G. W. & Barrett, K. C., 2007. *SPSS for introductory Statistics: Use and Interpretation.* 3rd ed. Mahwah, NJ: Lawrence Erlbaum Associates.

Morgen, J. M. & Liker, J. K., 2006. *The Toyota Product Development System.* 1st ed. New York: Productivity Press.

Mostafa, S., Dumrak, J. & Sultan , H., 2013. A framework for lean manufacturing implementation. *Prouction & Manufacturing Research,* 1(1), pp. 44-64.

Mtshali, S. G., 2011. *Implementing Lean Manufacturing Tecniques at Arcelormittal, Pretoria Works.* Pretoria: University of Pretoria.

Mund, K., 2011. *Tailoring a lean product development framework for the South African automotive industry.* s.l.:PhD, Nelson Mandela University.

Mungadze, S. & Mochiko, T., 2015. *FinancialMail.* [Online]
Available at: http://www.financialmail.co.za/coverstory/2015/04/02/digital-value-manec-stung-by-factions
[Accessed 19-05-2015 May 2015].

Mwacharo, F., 2013. *Challenges of lean management: Investigating the challenges and developing a recommendation for implementing lean management techniques.* s.l.:Bcom (SCM), HAMK University of Applied Sciences.

Nahmias, S., 2008. *Production and Operational Analysis.* 6th ed. London: McGraw Hill.

Naidoo, R., 2007. *The effect of China's Globalisation on the South African Coal Mining Equipment Industry.* 1st ed. North West: Potchefstroom Business School.

Naidoo, S., 2012. *Lean manufacturing as an alternative operation process: A small printing organization in Johhanesburg.* s.l.:MBA, Tshwane Univesity og Technology.

Nawanir, G., Teong, L. K. & Othman, S. N., 2013. "Impact of lean practises on operations performance and business performance: Some evidence from Indonesian manufacturing companies". *Journal of Manufacturing Technology Management,* 24(7), pp. 1019-1050.

Ndou, N., 2009. *Developing guidelines for implementing lean manufacturing of electrical transformers.* s.l.:MagEng, University of Johannesburg.

Neethling, G., 2009. *Performance improvement by applying lean manufacturing principles at Multitech.* s.l.:MBA, University of Stellenbosch.

Nenni, M. E., Giustiniano, L. & Pirolo, L., 2014. Improvement of Manufacturing Operations through Lean Management approach: A Case Study in the Pharmaceutical Industry. *International Journal of Engineering Business Management., https://doi.org/10.5772/59027.*

Nhlabathi, G., 2012. *Analysis and reduction of waste in the work process using kaizen tools: A case study.* s.l.:MTech, University of Johannesburg.

Ondiek, G. O. & Kisombe, S. M., 2013. A Survey on Adoption of Lean Manufacturing Tools and Techniques in Sugar Processing Industries in Keny. *Industrial Engineering Letters,* 3(10), pp. 92-104.

Oon, F., 2013. Perception on lean practises in lean implementation. *International Journal of Academic Reearch in Business and Social Sciences,* 3(11), pp. 554-570.

Palm, H., 2006. *The application, utilization and level of value adding of selected lean manufacturing techniques amongst assembly manufacturing in Gauteng.* s.l.:MBA, University of Johannesburg.

Papadopoulou, T. & Ozbayrak, M., 2005. Leanness: Experience from the journey to date. *Journal of Manufacturing Technology Management,* 16(7/8), pp. 784-808.

Patel, S., 2015. *Salma Patel.* [Online]
Available at: http://salmapatel.co.uk/academia/the-research-paradigm-methodology-epistemology-and-ontology-explained-in-simple-language
[Accessed 10 05 2017].

Pelled, L. & Adler, P., 1994. Antecedents of intergroup conflict in multifunctional product development teams: A conceptual model. *IEEE Transactions on Engineering Management,* 41(1), pp. 21-28.

Pereira, R., 2009. The seven Wastes. *iSIXSIGMA Magazine-The Skill Builder,* 5(5).

Phillip, J., 2012. *Root cause analysis of production defects in a foundary using lean tools.* s.l.:MSc, University of Cape Town.

Pingyu, A. Y. & Yu, B. Y., 2010. The barriers to SME's implementation of Lean production and counter measures. *International Journal of innovation, management and technology,* 1(2), pp. 220-225.

Poppendieck, M., 2002. *"Principles of Lean Thinking", Technical Report,* USA: Poppendieck LLC.

Popper, K. R., 1994. *The Myth of the Framework: In Defecence f Science and Rationality.* London: Routledge.

Puvanasvaran, P., Megat, H., Hong, T. & Razali, M., 2009. The roles of the communiation process for effective lean manufacturing implementation. *Journal of Industrial Engineering and management,* 2(1), pp. 229-241.

Radnor, Z., Wally, P., Stephens, A. & Bucci, G., 2006. *Evaluation of the lean approach to business management and its use in the public sector.* s.l.:Scottish Executive Social Research.

Rahman, S., Laosirihongthong, T. & Sohal, A. S., 2010. Impact of lean strategy on operational performance: a study of Thai manufacturing companies. *Journal of Manufacturing Technology Management,* 21(7), pp. 839-852.

Ramdass, K., 2007. *An engineering management framework for the SA clothing industry with a focus on Kwazulu Natal.* 1st ed. Johannesburg: University of Johannesburg.

Rathilall, R., 2011. *Improving Quality and Productivity through Lean Manufacturing at an Automotive Manufacturing organisation in Durban.* 1st ed. Durban: Durban University of Technology.

Revelle, J. B., 2002. *Manufacturing Handbook of Best Practices: An Innovation, productivity and Quality Focus.* Florida: CRC Press LLC.

Richards, L., 2005. *Handling Qualitative Data: A Practical Guide.* 1st ed. London: Sage.

Roberts, M., 2012. *LNS Research.* [Online]
Available at: http://blog.lnsresearch.com/bid/146822/Top-6-Challenges-in-Electronics-Manufacturing
[Accessed 18 11 2015].

Rose, A. N. M., Deros, B. M. & Rahman, M. N. A., 2014. Critical success factors for implementing lean manufacturing in Malaysian automotive industry. *Research Journal of Applied Sciences, Engineering and Technology,* 8(10), pp. 1191-1200.

Ruiz-de-Arbulo-Lopez, P., Fortury-Santos, J. & Cuatrecasas-Arbos, L., 2013. Lean manufacturing: Costing the value stream. *Industrial Management and Data Systems,* 113(5), pp. 647-688.

Rymazewska, A., 2014. The challenges of lean manufacturing in SME's. *Benchmarking: An International Journal,* 21(6), pp. 987-1002.

Sanchez, A. & Perez, M., 2001. Lean indicators and manufacturing strategies. *International Journal of Operations Management,* 21(11), pp. 1433-1452.

Sangwan, K. S., Bhamu, J. & Mehta, D., 2014. Development of lean manufacturing implementation drivers for Indian ceramic industry. *International Journal of Productivity and Performance Management,* 63(5), pp. 569-587.

Santos, J. R. A., 1999. Cronbach's Alpha: a tool for assessing the reliability of scales. *Journal of Extension,* 37(2), pp. 1-6.

Sarkar, D., 2007. *Lean for Service Organizations and Offices: A Holistic approach for Achieving Operational Excellence and Improvements.* 1st ed. India: ASQ Quality Press.

Saunders, M. N. K., Lewis, P. & Thornhill, A., 2007. *Research methods for business students.* Harlow, England: Financial Times/Prentice Hall.

Scholtz, R., 2008. *The manufacturing performanc measurement matrix model.* s.l.:MBA, University of Stellenbosch.

Scott, F., Butler, J. & Edwards, J., 2001. Does lean production sacrifice learning in a manufacturing environment? An action learning case study. *Studies in Continuing Education,* 23(2), pp. 229-241.

Sekaran, U. & Bougie, R., 2010. *Research Methods for Business.* 5th ed. United Kingdom: John Wiley and Sons.

Shah, R. & Ward, P. T., 2007. Defining and devloping measures of lean production. *Journal of operations management,* Volume 25, pp. 785-805.

Simon, H., 2009. *Case Study Research in Practise.* London: Sage.

Singh, B., Garg, S., Sharma, S. & Grewal, C., 2010. Lean Implementation and its benefits to production industry.. *International Journal of Lean Six Sigma,* 1(2), pp. 157-168.

Skogmalm, M., 2015. *Knowledge management within a Lean organization: a case study at Volvo cars.* Sweden: Linnaeus University.

Soriana-Meier, H. & Forrester, P., 2002. A model for evaluating the degree of leanness of the manufacturing firms. *Integrated and Manufacturing systems,* 13(2), pp. 104-109.

Spear, S. & Bowen, H., 1999. Decoding the DNA of the Toyota production system. *Harvard Business Review,* pp. 1-12.

Stake, R. E., 1995. *The Art of Case Study Research.* housands Oaks, CA: Sage.

Steinke, I., 2004. *"Quality criteria in qualitative research".A companion to qualitative research.* London:, Sage Publications, pp. 184-190.

Sternberg , H. et al., 2012. Applying a lean approach to idenify waste in motor carrier operations. *International Journal of Productivity and Performance Management,* 62(1), pp. 47-65.

Steyn, P. & Du Toit, A., 2010. Investigating the potential for the development of a just in time knowledge management model. *South African Journal of Business management,* 41(2), pp. 1-12.

Struebing, L. & Klaus, L. A., 1997. Smaller businesses thinking big. *Quality Progress*, February, pp. 23-27.

Taggart, P., 2009. *The effectiveness of lean manufacturing audits in driving improvemenst in operational performance.* s.l.:MSc (Eng), University of Witwatersrand.

Taj, S., 2008. Lean manufacturing performance in China: assessment of 65 manufacturing plants. *Journal of Manufacturing Technology,* 19(2), pp. 217-234.

Taj, S. & Morosan, C., 2011. The Impact of lean operations on the China manufacturing. *Journal of Manufacturing Technology Management,* 22(2), pp. 223-240.

Thun, J., Druke , M. & Grubner, A., 2010. Empowering Kanban through TPS principles: An empirical analysis of the Toyota Production System. *Journal of Production Research,* 48(23), pp. 7089-7106.

Tinoco, J., 2004. *Implementation of lean manufacturing.* s.l.:MSc, University of Wisconsin-Stout.

Tirvengadum, P., 2014. *Nex TV News Africa and Middle East.* [Online]
Available at: http://nextvame.com/stb/altech-celebrates-20-millionth-set-top-box/
[Accessed 18 11 2015].

Tiwari, A., Turner, C. & Sackett, P., 2007. "A framework for implementing cost and quality practices within manufacturing". *Journal of Manufacturing Technology Management,* 18(6), pp. 731-760.

Toke, L. C., Gupta, R. C. & Dandekar, M., 2012. An empirical study of green supply chain management in Indian. *International Journal of Applied Sciences and Engineerimg Research,* 1(2), pp. 372-383.

Toralla, M. & Morais, A., 2012. Participatory design in lean production: Which contribution from employees? For what end?. *Work,* Volume 41, pp. 2706-2712.

Tredoux, C. & Durrheim, K., 2006. *Numbers, Hypotheses & Conclusions: A Course in Statictics for Social Sciences.* 1 ed. Cape Town: UCT Press.

Trochim, W., 2006. *Social Methods Knowledge Base.* [Online]
Available at: http:///www.socialresearchmethods.net/kb/contents.php
[Accessed 15 November 2016].

Vahed, P., 2012. *Cntinuous improvement and employee attitudes in a manufacturing concern.* s.l.:MBA, North-West University.

Van der Walt, A., 2012. *Implementing lean best practises in an automotive component parts manufacturing company.* s.l.:BEng, University of Pretoria.

Van Staden, G., 2012. *A lean approach to manufacturing optimization.* s.l.:Cosira Group, South Africa.

Vermaak, T., 2008. *Critical success factors for the implementation of lean thinking in South African manufacturing organizations.* s.l.:PhD, University of South Africa.

Vienazindiene, M. & Ciarniene, R., 2013. Lean manufacturing implementation and progress measurement. *Economics Management,* 18(2), pp. 366-373.

Ward, P. & Zhou, H., 2006. Impact of Information Technology Integration and Lean/Just-in-Time Practises on Lead-Time Performance. *Decision Sciences,* 37(2), pp. 177-203.

Wedgwood, I. D., 2007. *Lean Sigma: A Practitioner's Guide.* New Jersey: Pearson Education.

Welman, C., Kruger, F. & Mitchell, B., 2005. *Research Methodology.* 3rd ed. Cape Town: Oxford University Press.

White, R. & Pearson, J., 2001. Just in time system integration and customer. *International Journal of Physical Distribution and Logistics Management,* 31(5), pp. 313-333.

Wilkinson, D. & Birmingham, P., 2003. *Using Research Instruments: A Guide for Researchers.* London: Routledge.

Womack, J. P. & Jones, D. T., 1996. *Lean Thinking: Banish Waste and Create Wealth in Your Corporation.* London: Simon and Schuster.

Womack, J. P. & Jones, D. T., 2003. *Lean Thinking: Banish Waste and Create Wealth in Your Corporation.* 2nd ed. London: Simon and Schuster.

Wong, Y. C., Wong, K. Y. & Ali, A., 2009. A Study on Lean Manufacturing Implementation in the Malaysian Electrical and Electronics Industry. *European Journal of Scientific Research,* 38(4), pp. 521-535.

Wong, Y. & Wong, K., 2011. Approaches and practises of lean kanufacturing: The case of electrical and electronics companies. *African Journal of Business Management,* 5(6), pp. 2164-2174.

Worley, J. & Doolen, T., 2006. The role of communication and management: Support in a lean manufacturing implementation. *Management Decision,* 44(22), pp. 228-247.

Wu, Y., 2003. Lean manufacturing: A perspective of lean suppliers. *International Journal of Operations and Production Management,* 23(11), pp. 1349-1376.

Yang, P. & Yu, Y., 2010. The barriers to SME's implementtion of lean production and countermeasures: Based on SME's in Wenshou. *International Journal of Innovation Management and Technology,* 1(2), pp. 220-225.

Yavuz, M. & Akcali, E., 2007. Production smoothing in just in time manufacturing systems: A review of the models and solution approaches. *International Journal of Production Research,* 45(16), pp. 3579-3597.

Yin, R., 1984. *Case Study Research: Design and methods.* Newbury Park,CA: Sage.

Yin, R. K., 2003. *Case Study Research Design and Methods.* 3rd ed. Thousands Oaks, CA: Sage.

Yin, R. K., 2014. *Case Study Research: Design and Methods.* 5th ed. Thousands Oaks, CA: Sage Publishers.

Yusof, S. M. & Aspinwall, E., 2000. Total quality management implementation fraeworks: comparison and review. *Total Quality Management,* 11(3), pp. 281-294.

Zikmund, W. G., 2003. *Business Research Methods.* Thomson South Western, Ohio: Mason.

Zikmund, W. G. & Babin, B. J., 2010. *Exloring marketing research.* 10 ed. South -Western/Cengage: Mason, Ohio; Australia.

Appendix: 1

Rotated Component Matrix

Question: 1	Component 1	Component 2
Work in progress Inventory is kept to a minimum	0.840	-0.123
All purchasing are via MRP or sales order	-0.253	0.671
Lot sizes are continuously monitored and reduced to keep inventory down	0.801	-0.105
The number of times parts are transported within the different manufacturing cells are kept to a minimum	0.906	-0.032
The shortest distances are maintained to transport parts within the different manufacturing cells	0.851	0.008
Manufacturing cycle times are kept to a minimum. Employees do not spend excessive time waiting for a cycle to be completed	0.040	0.782
All tools and processes are capable of producing quality goods	0.112	0.837
Defects resulting in scrap and rework are constantly monitored	0.676	0.097

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 3 iterations.

Question: 2	Component 1	Component 2
All employees are involved in continuous improvement activities	0.852	-0.138
Since employees have first-hand knowledge of their processes their views are never underestimated by management	0.764	-0.291
Appropriate feedback is consistently provided on continuous improvement initiatives	0.843	-0.172
All employees have been trained on continuous improvement	0.748	0.055
The number of suggestions per employee is monitored	0.800	-0.023
Operators gather in groups to come up with suggestions on possible improvements	0.773	0.129
The PDCA methodology is consistently used to address problems and close them off consistently	-0.214	0.775
The 5S methodology is used to maintain a clean and organised working environment	0.109	0.841

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 3 iterations.

Question: 3	Component 1	Component 2	Component 3
Operators are responsible to identify defective parts at the source of the operation	-0.363	0.778	0.040
Operators are permitted to stop the line in the event that defective parts are noticed	0.870	0.007	0.117
Defective parts are reworked at the workstation where the defect was identified	0.898	-0.094	-0.058
Measuring and inspection is carried out at the end of every process and after the product is fully assembled	-0.059	0.274	0.730
Autonomous defect control such as Poke-Yoke devices are used as a majority source of inspection methodology	0.106	-0.122	0.832
Operators are responsible for quality.	0.171	0.883	0.078

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 4 iterations.

Question: 4	Component
	1
Each process is provided with the required part, in the correct quantity at the exact point in time	0.782
Production lot sizes, buffer sizes and order lead time are continuously reduced to ensure just-in-time production	0.856
suppliers deliver at the time of consumption	0.832
All processes use a pull system rather than push	0.862
Inventory levels between work centres are kept to minimum	0.865

Extraction Method: Principal Component Analysis.
a. 1 component extracted.

Question: 5	Component		
	1	2	3
Multifunctional teams exist within the organisation and are arranged at the different manufacturing processes	0.901	0.079	0.020
The number of employees working in multifunctional teams should increase	0.035	0.039	0.983
Employees within Multifunctional teams perform many different tasks in the product flow	0.909	-0.017	0.047
Tasks are rotated amongst multifunctional team members	0.859	0.141	-0.010
There is no reliance or dependence on single employees performing a specific task	0.454	0.647	-0.190
Employees are trained in performing various tasks in the production process	0.762	0.401	-0.024
Teamwork promotes trust, support, respect and collaboration	-0.024	0.906	0.146

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 4 iterations.

Question: 6	Component
	1
Operators are responsible for planning, maintenance, inspection and quality to prevent the disruption of product flow	0.806
Supervisory tasks are performed by multifunctional teams through rotating team leadership among employees especially trained for that specific task	0.830
The number of hierarchical levels in the organisation is kept to a minimum	0.753
Operators are encouraged to make decisions concerning production, quality and maintenance	0.653
Employees have real influence and power when they participate in decision making instead of serving as consultants	0.522

Extraction Method: Principal Component Analysis.
a. 1 component extracted.

Question: 7	Component
	1
Indirect tasks such as materials handling, planning, maintenance, and quality control, are performed by multifunctional teams.	0.676
The number of tasks performed by multifunctional teams should increase, thus reducing the ratio of indirect employees to direct employees	0.512
Employees are constantly rotated to perform many different tasks	0.777
Sufficient training is provided to multi-skill employees	0.800
Employees are rewarded for learning new skills	0.775
Multi-skilled employees are given the opportunity to perform job rotation	0.824

Extraction Method: Principal Component Analysis.

a. 1 component extracted.

Question: 8	Component	
	1	2

The organisation is transparent in all aspects of the business	-0.093	0.849
Strategic information such as the organisations market plans, and financial performance is provided to all employees	0.273	0.733
Operational information such as productivity, timeliness and quality is provided to all employees	0.896	0.137
Information is continually displayed in dedicated spaces, directly in the production flow and this is discussed at regular meetings	0.894	0.029
Visual communication is common throughout each process	0.843	0.071

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 3 iterations.

Question: 9	Component
	1
All employees within the organisation have profound knowledge on how the pull system works	0.782
The organisation manufactures products to actual customer demand rather than to forecasts	0.430
Each workstation pulls the output from the preceding process as it is needed during production	0.853
A Kanban card system is used to signal material replenishment	0.912
Small lot quantities are used as a strategy to detect defects faster	0.892

Extraction Method: Principal Component Analysis.

a. 1 component extracted.

Question: 10	Component	
	1	2
At our plant we are concerned about keeping all components, tools and instrument in their place	0.001	0.863
Our areas are clean and tidy	-0.065	0.858
There are updated graphs near thee equipment indicating down time	0.933	-0.024
There are updated graphs near the work station indicating defects	0.946	-0.046
There are updated graphs near the work station indicating production level	0.940	-0.034

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 3 iterations.

Question: 11	Component	
	1	2
An effort is made to reduce the time spent for change overs	0.008	0.998
Workers are trained to make quick batch changes and they practise to reduce the time they invest in this task	0.952	-0.008
Managers give importance to batch change time reduction	0.921	-0.060
The machinery used is always ready to be used in manufacturing	0.910	0.092

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 3 iterations.

Question: 12	Component	
	1	2

A clear strategy is in place by which to evaluate supplier performance in terms of quality, delivery and price	0.765	-0.108
Local suppliers are used to avoid shipment deliveries	-0.168	0.841
Raw materials are received on time from date of orders	0.802	-0.212
Suppliers are provided with feedback regarding quality and delivery	0.880	-0.163
Raw materials and purchased parts are not subject to incoming inspection	-0.159	0.852

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 3 iterations.

Question: 13	Component
	1
We have close work relationships with our customers (frequent and direct contact, mutual visits to our respective plants, collaboration agreements)	0.485
We survey or diagnose our customers' needs or requirements	0.922
Our organisation processing is integrated with that of the customer	0.876
Customers provide us with feedback on product quality, delivery timing	0.228

Extraction Method: Principal Component Analysis.

a. 1 component extracted.

Question: 14	Component
	1
In the organisation there are regulations supporting innovative ideas research and exploitation	0.840
We use information systems or data bases that allow knowledge to widespread through the organisation	0.833
There are groups of workers that continuously have access, put into practise and update their working knowledge	0.859
We use formal mechanisms in order to share the best practises amongst the organisation personnel	0.900

Extraction Method: Principal Component Analysis.

a. 1 component extracted.

Appendix:2

Pearson Chi-square tests

Questions		Department	Position
Work in progress Inventory is kept to a minimum	Chi-square	70.854	55.048
	df	36	24
	Sig.	.000*	.000*
All purchasing are via MRP or sales order	Chi-square	13.748	16.522
	df	27	18
	Sig.	0.984	0.556
Lot sizes are continuously monitored and reduced to keep inventory down	Chi-square	73.779	59.130
	df	36	24
	Sig.	.000*	.000*
The number of times parts are transported within the different manufacturing cells are kept to a minimum	Chi-square	48.333	51.505
	df	36	24
	Sig.	0.082	.001*
The shortest distances are maintained to transport parts within the different manufacturing cells	Chi-square	59.240	59.411
	df	36	24
	Sig.	.009*	.000*
Manufacturing cycle times are kept to a minimum. Employees do not spend excessive time waiting for a cycle to be completed	Chi-square	64.370	29.153
	df	36	24
	Sig.	.003*	0.214
All tools and processes are capable of producing quality goods	Chi-square	19.615	19.515
	df	36	24
	Sig.	0.988	0.724
Defects resulting in scrap and rework are constantly monitored	Chi-square	57.993	38.359
	df	36	24
	Sig.	.012*	.032*
All employees are involved in continuous improvement activities	Chi-square	57.577	32.465
	df	36	24
	Sig.	.013*	0.116
Since employees have first-hand knowledge of their processes their views are never underestimated by management	Chi-square	45.022	23.106
	df	36	24
	Sig.	0.144	0.514
Appropriate feedback is consistently provided on continuous improvement initiatives	Chi-square	36.047	35.413
	df	36	24
	Sig.	0.466	0.063
All employees have been trained on continuous improvement	Chi-square	59.143	57.128
	df	36	24

	Sig.	.009*	.000*
The number of suggestions per employee is monitored	Chi-square	61.605	37.600
	df	36	24
	Sig.	.005*	.038*
Operators gather in groups to come up with suggestions on possible improvements	Chi-square	58.765	58.156
	df	36	24
	Sig.	.010*	.000*
The PDCA methodology is consistently used to address problems and close them off consistently	Chi-square	57.559	36.803
	df	36	24
	Sig.	.013*	.046*
The 5S methodology is used to maintain a clean and organised working environment	Chi-square	27.128	24.726
	df	27	18
	Sig.	0.457	0.133
Operators are responsible to identify defective parts at the source of the operation	Chi-square	33.887	29.185
	df	36	24
	Sig.	0.569	0.213
Operators are permitted to stop the line in the event that defective parts are noticed	Chi-square	49.740	39.483
	df	36	24
	Sig.	0.063	.024*
Defective parts are reworked at the workstation where the defect was identified	Chi-square	51.360	36.910
	df	36	24
	Sig.	.047*	.045*
Measuring and inspection is carried out at the end of every process and after the product is fully assembled	Chi-square	43.814	34.552
	df	36	24
	Sig.	0.174	0.075
Autonomous defect control such as Poke-Yoke devices are used as a majority source of inspection methodology	Chi-square	29.378	16.280
	df	36	24
	Sig.	0.775	0.878
Operators are responsible for quality.	Chi-square	30.486	21.536
	df	36	24
	Sig.	0.728	0.607
Each process is provided with the required part, in the correct quantity at the exact point in time	Chi-square	46.448	70.868
	df	36	24
	Sig.	0.114	.000*
Production lot sizes, buffer sizes and order lead time are continuously reduced to ensure just-in-time production	Chi-square	49.945	112.623
	df	36	24
	Sig.	0.061	.000*
suppliers deliver at the time of consumption	Chi-square	52.603	61.534
	df	36	24
	Sig.	.036*	.000*

All processes use a pull system rather than push	Chi-square	63.829	119.370
	df	36	24
	Sig.	.003*	.000*
Inventory levels between work centres are kept to minimum	Chi-square	52.354	72.630
	df	36	24
	Sig.	.038*	.000*
Multifunctional teams exist within the organisation and are arranged at the different manufacturing processes	Chi-square	52.723	85.205
	df	36	24
	Sig.	.036*	.000*
The number of employees working in multifunctional teams should increase	Chi-square	20.960	15.019
	df	27	18
	Sig.	0.788	0.661
Employees within Multifunctional teams perform many different tasks in the product flow	Chi-square	92.413	59.633
	df	36	24
	Sig.	.000*	.000*
Tasks are rotated amongst multifunctional team members	Chi-square	31.849	46.538
	df	36	24
	Sig.	0.666	.004*
There is no reliance or dependence on single employees performing a specific task	Chi-square	65.289	49.506
	df	36	24
	Sig.	.002*	.002*
Employees are trained in performing various tasks in the production process	Chi-square	43.489	67.198
	df	36	24
	Sig.	0.183	.000*
Teamwork promotes trust, support, respect and collaboration	Chi-square	41.604	21.339
	df	36	24
	Sig.	0.24	0.619
Operators are responsible for planning, maintenance, inspection and quality to prevent the disruption of product flow	Chi-square	22.184	87.681
	df	36	24
	Sig.	0.966	.000*
Supervisory tasks are performed by multifunctional teams through rotating team leadership among employees especially trained for that specific task	Chi-square	44.900	51.436
	df	36	24
	Sig.	0.147	.001*
The number of hierarchical levels in the organisation is kept to a minimum	Chi-square	45.692	125.546
	df	36	24
	Sig.	0.129	.000*
Operators are encouraged to make decisions concerning production, quality and maintenance	Chi-square	38.643	12.560
	df	36	24
	Sig.	0.351	0.973
Employees have real influence and power when they	Chi-	72.021	42.482

participate in decision making instead of serving as consultants	square		
	df	36	24
	Sig.	.000*	.011*
Indirect tasks such as materials handling, planning, maintenance, and quality control, are performed by multifunctional teams.	Chi-square	44.590	41.471
	df	36	24
	Sig.	0.154	.015*
The number of tasks performed by multifunctional teams should increase, thus reducing the ratio of indirect employees to direct employees	Chi-square	57.624	71.699
	df	36	24
	Sig.	.013*	.000*
Employees are constantly rotated to perform many different tasks	Chi-square	39.549	50.628
	df	36	24
	Sig.	0.314	.001*
Sufficient training is provided to multi-skill employees	Chi-square	47.990	74.390
	df	36	24
	Sig.	0.087	.000*
Employees are rewarded for learning new skills	Chi-square	60.727	60.534
	df	36	24
	Sig.	.006*	.000*
Multi-skilled employees are given the opportunity to perform job rotation	Chi-square	67.578	82.390
	df	36	24
	Sig.	.001*	.000*
The organisation is transparent in all aspects of the business	Chi-square	37.759	62.206
	df	36	24
	Sig.	0.389	.000*
Strategic information such as the organisations market plans, and financial performance is provided to all employees	Chi-square	59.023	37.040
	df	36	24
	Sig.	.009*	.043*
Operational information such as productivity, timeliness and quality is provided to all employees	Chi-square	60.086	57.798
	df	36	24
	Sig.	.007*	.000*
Information is continually displayed in dedicated spaces, directly in the production flow and this is discussed at regular meetings	Chi-square	118.597	107.857
	df	36	24
	Sig.	.000*	.000*
Visual communication is common throughout each process	Chi-square	56.117	52.967
	df	36	24
	Sig.	.017*	.001*
All employees within the organisation have profound knowledge on how the pull system works	Chi-square	55.300	44.319
	df	36	24
	Sig.	.021*	.007*
The organisation manufactures products to actual customer demand rather than to forecasts	Chi-square	61.700	86.866

	df	36	24
	Sig.	.005*	.000*
Each workstation pulls the output from the preceding process as it is needed during production	Chi-square	39.863	28.066
	df	36	24
	Sig.	0.302	0.257
A Kanban card system is used to signal material replenishment	Chi-square	58.961	25.577
	df	27	18
	Sig.	.000*	0.11
Small lot quantities are used as a strategy to detect defects faster	Chi-square	68.861	46.026
	df	36	24
	Sig.	.001*	.004*
At our plant we are concerned about keeping all components, tools and instrument in their place	Chi-square	56.732	33.335
	df	36	24
	Sig.	.015*	0.097
Our areas are clean and tidy	Chi-square	35.684	24.171
	df	27	18
	Sig.	0.122	0.149
There are updated graphs near thee equipment indicating down time	Chi-square	53.700	36.703
	df	36	24
	Sig.	.029*	.047*
There are updated graphs near the work station indicating defects	Chi-square	44.862	35.624
	df	36	24
	Sig.	0.148	0.06
There are updated graphs near the work station indicating production level	Chi-square	63.682	39.548
	df	36	24
	Sig.	.003*	.024*
An effort is made to reduce the time spent for change overs	Chi-square	21.470	26.353
	df	27	18
	Sig.	0.764	0.092
Workers are trained to make quick batch changes and they practise to reduce the time they invest in this task	Chi-square	49.089	44.704
	df	36	24
	Sig.	0.072	.006*
Managers give importance to batch change time reduction	Chi-square	67.885	52.332
	df	36	24
	Sig.	.001*	.001*
The machinery used is always ready to be used in manufacturing	Chi-square	45.333	40.663
	df	36	24
	Sig.	0.137	.018*
A clear strategy is in place by which to evaluate supplier performance in terms of quality, delivery and price	Chi-square	30.094	23.045
	df	27	18

	Sig.	0.31	0.189
Local suppliers are used to avoid shipment deliveries	Chi-square	81.586	44.162
	df	36	24
	Sig.	.000*	.007*
Raw materials are received on time from date of orders	Chi-square	36.331	51.083
	df	27	18
	Sig.	0.108	.000*
Suppliers are provided with feedback regarding quality and delivery	Chi-square	38.266	38.063
	df	27	18
	Sig.	0.074	.004*
Raw materials and purchased parts are not subject to incoming inspection	Chi-square	75.273	35.819
	df	36	24
	Sig.	.000*	0.057
We have close work relationships with our customers (frequent and direct contact, mutual visits to our respective plants, collaboration agreements)	Chi-square	22.136	24.533
	df	36	24
	Sig.	0.966	0.431
We survey or diagnose our customers' needs or requirements	Chi-square	40.601	35.420
	df	36	24
	Sig.	0.275	0.062
Our organisation processing is integrated with that of the customer	Chi-square	31.510	41.678
	df	27	18
	Sig.	0.251	.001*
Customers provide us with feedback on product quality, delivery timing	Chi-square	31.162	47.453
	df	36	24
	Sig.	0.698	.003*
In the organisation there are regulations supporting innovative ideas research and exploitation	Chi-square	43.369	43.734
	df	36	24
	Sig.	0.186	.008*
We use information systems or data bases that allow knowledge to widespread through the organisation	Chi-square	41.379	41.386
	df	36	24
	Sig.	0.247	.015*
There are groups of workers that continuously have access, put into practise and update their working knowledge	Chi-square	53.766	60.593
	df	36	24
	Sig.	.029*	.000*
We use formal mechanisms in order to share the best practises amongst the organisation personnel	Chi-square	54.230	60.819
	df	36	24
	Sig.	.026*	.000*

Appendix: 3

19 November 2015

Dear Respondent,

I am current a Masters student at Durban University of Technology. I am engaging in a study '**The adoption of lean manufacturing principles in electronic manufacturing: a case of Altech UEC'.**

I would appreciate if you would kindly complete the attached questionnaire. All feedback in the questionnaire will be private and confidential. If you are not comfortable with completing the questionnaire please hand the blank questionnaire back to your supervisor.

The questions are grouped into sections. Please indicate the extent to which you agree or disagree with each of the statements/phrases provided by placing a cross in the appropriate column.

Section 1:

Please mark a cross for appropriate department	
Logistics	
Stores	
Quality Control	
SMD /AI / Testing	
Enclosures	
Final Integration	
Despatch	
Process Engineering	
Test Engineering	
Material Planning	

Section 2:

Position	
Operator	
Section Manager	
Engineer	
Inspector	
Administration	
Section leader / Supervisor	
Technician	

Section 3:

1	**Elimination of Waste :** Any activity in production that does not add value to the finished product, such as excess inventory, unnecessary movements of employees, scrap, rework or transportation	Strongly Disagree	Disagree	Not sure	Agree	Strongly Agree
1.1	Work in progress Inventory is kept to a minimum					
1.2	All purchasing are via MRP or sales order					
1.3	Lot sizes are continuously monitored and reduced to keep inventory down					
1.4	The number of times parts are transported within the different manufacturing cells are kept to a minimum					
1.5	The shortest distances are maintained to transport parts within the different manufacturing cells					
1.6	Manufacturing cycle times are kept to a minimum. Employees do not spend excessive time waiting for a cycle to be					
1.7	All tools and processes are capable of producing quality goods					
1.8	Defects resulting in scrap and rework are constantly monitored					

2	**Continuous Improvement:** Continuous improvement is an ongoing effort to improve products, services or processes.	Strongly Disagree	Disagree	Not sure	Agree	Strongly Agree
2.1	All employees are involved in continuous improvement activities					
2.2	Since employees have first-hand knowledge of their processes their views are never underestimated by management					
2.3	Appropriate feedback is consistently provided on continuous improvement initiatives					
2.4	All employees have been trained on continuous improvement					
2.5	The number of suggestions per employee is monitored					
2.6	Operators gather in groups to come up with suggestions on possible improvements					

2.7	The PDCA methodology is consistently used to address problems and close them off consistently					
2.8	The 5S methodology is used to maintain a clean and organised working environment					

3	**Zero Defects:** Zero defects is a way of thinking and doing production tasks right the first time without manufacturing defects. This philosophy increases the organisations profits by eliminating the cost of failure	Strongly Disagree	Disagree	Not sure	Agree	Strongly Agree
3.1	Operators are responsible to identify defective parts at the source of the operation					
3.2	Operators are permitted to stop the line in the event that defective parts are noticed					
3.4	Defective parts are reworked at the workstation where the defect was identified					
3.5	Measuring and inspection is carried out at the end of every process and after the product is fully assembled					
3.6	Autonomous defect control such as Poke-Yoke devices are used as a majority source of inspection methodology					
3.7	Operators are responsible for quality.					

4	**Just-in-time:** It is a concept that controls inventory and material flow throughout the entire organisation. The philosophy involves providing the required part, in the correct quantity at the exact point in time.	Strongly Disagree	Disagree	Not sure	Agree	Strongly Agree
4.1	Each process is provided with the required part, in the correct quantity at the exact point in time					
4.2	Production lot sizes, buffer sizes and order lead time are continuously reduced to ensure just-in-time production					
4.3	suppliers deliver at the time of consumption					
4.4	All processes use a pull system rather than push					
4.5	Inventory levels between work centres are kept to minimum					

5	**Multifunctional teams:** A group of employees that are organised in a particular work area and are able to perform many different tasks. These teams are often organised along a cell based part of the product flow	Strongly Disagree	Disagree	Not sure	Agree	Strongly Agree
5.1	Multifunctional teams exist within the organisation and are arranged at the different manufacturing processes					
5.2	The number of employees working in multifunctional teams should increase					
5.3	Employees within Multifunctional teams perform many different tasks in the product flow					
5.4	Tasks are rotated amongst multifunctional team members					
5.5	There is no reliance or dependence on single employees performing a specific task					
5.6	Employees are trained in performing various tasks in the production process					
5.7	Teamwork promotes trust, support, respect and collaboration					

6	**Decentralised responsibilities:** The process of transferring and assigning decision-making authority to lower level employees in an organisation hierarchy.	Strongly Disagree	Disagree	Not sure	Agree	Strongly Agree
6.1	Operators are responsible for planning, maintenance, inspection and quality to prevent the disruption of product flow					
6.2	Supervisory tasks are performed by multifunctional teams through rotating team leadership among employees especially trained for that specific task					
6.3	The number of hierarchical levels in the organisation is kept to a minimum					
6.4	Operators are encouraged to make decisions concerning production, quality and maintenance					
6.5	Employees have real influence and power when they participate in decision making instead of serving as consultants					

7	**Integrated functions:** A philosophy that enables employees to perform many different tasks –	Strongly Disagree	Disagree	Not sure	Agree	Strongly Agree
7.1	Indirect tasks such as materials handling, planning, maintenance, and quality control, are performed by multifunctional teams.					
7.2	The number of tasks performed by multifunctional teams should increase, thus reducing the ratio of indirect employees to direct employees					
7.3	Employees are constantly rotated to perform many different tasks					
7.4	Sufficient training is provided to multi-skill employees					
7.5	Employees are rewarded for learning new skills					
7.6	Multi-skilled employees are given the opportunity to perform job rotation					

8	**Vertical information systems:** The transfer of information to all employees within the organisation	Strongly Disagree	Disagree	Not sure	Agree	Strongly Agree
8.1	The organisation is transparent in all aspects of the business –					
8.2	Strategic information such as the organisations market plans, and financial performance is provided to all employees					
8.3	Operational information such as productivity, timeliness and quality is provided to all employees					
8.4	Information is continually displayed in dedicated spaces, directly in the production flow and this is discussed at regular meetings					
8.5	Visual communication is common throughout each process					

9	**Pull Instead of Push:** A philosophy that emphasises production planning to manufacture to order instead of manufacturing to stock. No one upstream should produce a part until the customer downstream requests for it	Strongly Disagree	Disagree	Not sure	Agree	Strongly Agree
9.1	All employees within the organisation have profound knowledge on how the pull system works					
9.2	The organisation manufactures products to actual customer demand rather than to forecasts					

9.3	Each workstation pulls the output from the preceding process as it is needed during production					
9.4	A Kanban card system is used to signal material replenishment					
9.4	Small lot quantities are used as a strategy to detect defects faster					

10	**Visual Management:** Displaying data and other information for all to see	Strongly Disagree	Disagree	Not sure	Agree	Strongly Agree
10.1	At our plant we are concerned about keeping all components, tools and instrument in their place					
10.2	Our areas are clean and tidy					
10.3	There are updated graphs near thee equipment indicating down time					
10.4	There are updated graphs near the work station indicating defects					
10.5	There are updated graphs near the work station indicating production level					
11	**SMED:** Quick change overs- reduced downtime	Strongly Disagree	Disagree	Not sure	Agree	Strongly Agree
11.1	An effort is made to reduce the time spent for change overs					
11.2	Workers are trained to make quick batch changes and they practise to reduce the time they invest in this task					
11.3	Managers give importance to batch change time reduction					
11.4	The machinery used is always ready to be used in manufacturing					

12	**Supplier Relations:** Engagement with suppliers and supplier development	Strongly Disagree	Disagree	Not sure	Agree	Strongly Agree
12.1	A clear strategy is in place by which to evaluate supplier performance in terms of quality, delivery and price					
12.2	Local suppliers are used to avoid shipment deliveries					
12.3	Raw materials are received on time from date of orders					
12.4	Suppliers are provided with feedback regarding quality and delivery					
12.5	Raw materials and purchased parts are not subject to incoming inspection					

13	**Customer Relations:** Customer interactions	Strongly Disagree	Disagree	Not sure	Agree	Strongly Agree
13.1	We have close work relationships with our customers (frequent and direct contact, mutual visits to our respective plants, collaboration agreements)					
13.2	We survey or diagnose our customers' needs or requirements					
13.3	Our organisation processing is integrated with that of the customer					
13.4	Customers provide us with feedback on product quality, delivery timing					

14	**Knowledge Management:** Training and organisation information	Strongly Disagree	Disagree	Not sure	Agree	Strongly Agree
14.1	In the organisation there are regulations supporting innovative ideas research and exploitation					
14.2	We use information systems or data bases that allow knowledge to widespread through the organisation					
14.3	There are groups of workers that continuously have access, put into practise and update their working knowledge					
14.4	We use formal mechanisms in order to share the best practises amongst the organisation personnel					

Thank you for your participation

Appendix: 4

18th November 2015

ALTECH UEC

Durban University of Technology
Faculty of Management Sciences
Department of Operations and Quality Management
ML Sultan Campus

To whom it may concern:

Dear Sir / Madam

This is confirm that Vanesh Naicker, DUT Graduate student, has permission of Altech UEC South Africa to conduct research at our Manufacturing Facility for his study: "The adoption of lean manufacturing principles in electronic manufacturing : a case of Altech UEC'

If you have any questions and concerns, please feel free to contact my office at (031) 5081306

Sincerely

[redacted]

Rajesh Ramkewal
Manufacturing Executive
031 508 1306
Email: Rajesh.Ramkewal@uec.co.za

altron
bmt

BYTES