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Exploring the effects of Lean Manufacturing Implementation on Productivity at GUD

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Abstract

The principles of lean manufacturing are primarily adapted from the Toyota Production System (TPS). In the manufacturing sector, lean implementation is one of the major enablers that helped companies become more productive. The term ‘productivity’ is used to describe how well the company makes use of the resources available and lean provides a way to do more with less.

There will be variation in the lean implementation process based on the fact that there is no consensus about the definition of lean. Selecting specific lean tools to implement, without understanding the broader system, limits the improvement in productivity achieved. GUD currently applies lean as a toolbox, used by a few skilled individuals in manufacturing. The aim of this research was to look at the factors that affect implementation of lean manufacturing to improve productivity at GUD.

Employee involvement, which includes employee training and teamwork, is one of the prerequisites to achieve lean success. Along with employee involvement, understanding what lean tools to implement and how to implement them is crucial to achieving productivity improvement. A cross-sectional study, using mixed methods research, was conducted at GUD Prospecton. A sample of 132 employees participated in a quantitative survey developed for the study, whilst three employees participated in a qualitative study.

The results of this study have revealed that the lean implementation process used at GUD can be described as Toolbox Lean and many of the tools commonly used in lean implementations have been used at GUD. A salient finding of the study was that most employees indicated they had received less than five hours of lean training since inception. According to findings, employee involvement in lean implementation has not been fully implemented at GUD, with some respondents also indicating a lack of teamwork, which is required to improve productivity.

It is recommended that GUD align the organisational strategy with lean implementation and spend time and resources in training all employees. Aligning the company strategy and engaging all employees is key to achieving continuous productivity improvement.

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CHAPTER 1

Introduction

1.1 Introduction

The total South African car imports grew from 61,749 in the year 2000 to 264,411 in 2016 (National Association of Automobile Manufacturers of South Africa, 2017:5). Local companies in the automotive industry are competing against imports and are looking at ways to improve productivity. Productivity is measured as the "rate of output per unit input" (Stevenson, 2015:56) and lean manufacturing is an approach to production that promises to deliver improved productivity (Coetzee, Van der Merwe, & Van Dyk, 2016:79). In simple terms, lean implementation offers a mechanism to achieve greater output with fewer inputs (Smith, 2011:1).

Lean was perfected by Toyota and first emerged in the early 1990s when professors from Massachusetts Institute of Technology (MIT) wrote a book on their findings from a study involving Toyota. Many people have concluded research on lean but there is still no clear definition for lean (Anvari, Ismail & Hojjati, 2011:1585) and no clear guideline on how to implement lean (Smith, 2011). A key principle of lean is continuous flow and a common thread amongst the definitions of lean is that implementing lean pertains to the removal of waste during manufacturing of a product (Smith, 2011).

Founded in 1949, GUD is an automotive filter manufacturer based in Prospecton, Durban. The company supplies filters to the South African aftermarket, overseas export markets and local car manufacturers. GUD started with the implementation of lean in 2014, with the aim of achieving manufacturing process and productivity improvement. In the GUD context, process improvement is defined as improving the flow of materials in manufacturing a filter and productivity improvement is a synonym for cost reduction. The lean methodology used at GUD was developed internally and the implementation focused on applying lean tools to individual projects.

Therefore, the primary objective of this research was to investigate the impact of implementing lean as a "toolbox" to improve productivity, in a manufacturing environment.

This chapter provides an overview of the research project and the motivation for this study. The focus of this study and the problem statement are also covered. The measurable outcomes required at the end of the research are also introduced. The chapter concludes with a brief description of the research methodology and an outline of subsequent chapters.

1.2 Motivation for the study

The local manufacturing industry is constantly under pressure to compete with cheaper imports. This is especially true in the automotive industry where local companies are competing with suppliers in developed countries.

Differences in culture and infrastructure between South African and developed countries require lean implementation to be customised to the specific needs of the company (Corbett, 2007:95). Adopting a lean implementation approach that does not address the needs of the company will result in frustration amongst workers as lean has a high dependency on employee involvement (Coetzee *et al*., 2016).

Pettersen (2009:127) asserted that there will be variation in the implementation process, based on the fact that there is no consensus about the definition of lean. Pettersen (2009) also advised that organisations should seek to adapt the lean philosophy to suit organisational needs. In contrast, Herron and Braident (2007:148) argued that adapting lean results in confusion, and not realising maximum benefits and sustainability.

According to Pearce and Pons (2013:49), poor understanding of the objectives of existing lean tools has resulted in inferior application of these tools. Understanding what lean tools implement and how to implement them is key to achieving lean success.

At GUD, lean is seen as a toolbox that the can be used as required to improve the current state of an operation. Currently, the lean toolbox is only used by a few skilled individuals in manufacturing. The lean methodology was developed for GUD internally and there is no record of the reasons for tool selection. There was never any link established between lean implementation and GUD's strategic objectives.

There is therefore a need to research lean, to develop a better understanding of the application of lean principles as a toolbox and how these tools can be adapted to improve productivity in a South African company. Currently, decisions are made without the full understanding of the long-term implications of the lean implementation approach. This research will allow companies like GUD to make an informed decision, with an improved understanding of how the lean implementation approach chosen can impact productivity.

The results of this research will benefit GUD managers and employees as the findings can be used to focus on improving the lean implementation processes at GUD. This can result in long-term, sustainable process and productivity improvement. The findings can also be used by other companies to improve their lean implementation results.

1.3 Focus of the study

The study was conducted at GUD Prospecton factory, focusing on the manufacturing assembly departments, as well as the departments that support manufacturing assembly. All personnel working in these areas made up the population being surveyed. In addition, interviews were conducted with three managers who were part of the team that developed GUD's lean toolbox.

Non-manufacturing departments such as purchasing and finance were excluded as these departments were not in scope for lean implementation at GUD.

This study focused on employee involvement, implementation processes and lean tools implemented at GUD to achieve manufacturing process and productivity improvement.

1.4 Problem statement

Although GUD has implemented lean as a toolbox for the past three years, the results achieved can be described as limited. Coetzee *et al.* (2016) found that selecting specific lean tools to implement without understanding the broader system, limits the improvement in productivity achieved, and eventually leads to frustration. This is similar to the findings of Herron and Braident (2007) who wrote that adapting lean results in confusion, and not realising maximum benefits. In contrast, other researchers like Corbett (2007) and Pettersen (2009) have emphasised customisation and tool selection for productivity improvement.

Emiliani (2013:407) concluded that lean is far more complicated to understand and practise than is suggested by research on the subject. Companies that implement lean as a toolbox do not see lean as a method for addressing customer needs and removing waste, and their failure to understand the meaning of lean is the main reason for implementation failures.

Another reason identified for lean failures is focusing on lean tools and not on employee involvement (Coetzee *et al.*, 2016). Employee involvement consists of employee training and including all employees in improvement initiatives (Schlichting, 2009:4). This view is supported by Radnor and Walley (2008:13) who found that that the lean journey is more than the implementation of tools. At GUD, the lean toolbox is only used by a few skilled individuals in manufacturing, with little employee involvement.

According to Schonberger (2007:403), clearly defining the link between lean and the operational performance measures they impact is difficult, making measuring the lean impact on productivity difficult. Furthermore, a focus on specific lean tools may lead companies away from industry-specific best practice.

Without understanding what lean tools to implement and how to implement them, GUD will continue investing resources in lean manufacturing without achieving the desired results. This will eventually result in management losing faith in lean as an approach to performance enhancement, and frustration amongst workers as lean has a high dependency on employee involvement.

This raises the following questions:

1. What effect has lean manufacturing implementation had on productivity at GUD?
2. Is there a link between lean manufacturing tool selection and the successful implementation of lean?
3. What role does employee involvement play in the successful implementation of lean?

1.5 Objectives

The aim of this study was to look at the factors that affect implementation of lean manufacturing to improve productivity. In order to address the research questions, the following objectives of the study were formulated:

- *To assess the existing manufacturing practices of GUD.*
- *To identify the lean manufacturing tools that impact productivity improvement at GUD.*
- *To identify the lean manufacturing implementation processes that impact productivity improvement at GUD.*
- *To determine how employee involvement in lean implementation enhances productivity at GUD.*

1.6 Methodology

A cross-sectional study was conducted at GUD Prospecton factory due to ease of access to the site. This study was conducted using mixed methods research. A questionnaire was used to gather quantitative data from staff at various organisational levels, using a quota sample of 132. The data collected was analysed to provide findings about the sample.

Qualitative data was gathered using a structured interview to collect information from managers who were part of the team that developed the lean toolbox. The aim was to explore the reasons the lean approach was chosen and what the expected outcomes were.

Ethical issues and prevention of bias were considered at different stages in the research process. In order to prevent sample bias, people in different departments and at different levels in the organisation were included in the sample.

1.7 Chapter outline

This dissertation is divided into six chapters. Chapter 1 provided a broad introduction to the topic and discussed the motivation for the study, the focus of the study, the problem statement, and the objectives of the study. A brief description of the methodology used in the study was also included.

Chapter 2 is a literature review on lean covering the definition of lean, origins of lean, the commonly used lean tools, lean implementation processes and the reason for lean failures and successes.

Chapter 3 provides an overview of the research methodology, and a justification for the approach and methods used in this study. This chapter details the research design and the research process adopted, and elaborates on the data collection and data analysis methods employed. The chapter concludes with a discussion on the ethical approach to the research.

The results of both the structured questionnaire and the structured interviews are presented in Chapter 4. The data is presented using tables and graphs. The results presented are discussed in Chapter 5, in relation to the previous research reviewed, and information available from the company. The discussion focuses on some of the major findings.

Chapter 6 provides a summary of the conclusions and recommendations from this study. The chapter concludes with recommendations for future research.

1.8 Summary

Lean manufacturing is an approach to production that promises to deliver improved productivity because lean implementation offers a mechanism to achieve greater output with fewer inputs. Lean is far more complicated to understand and practice than is suggested by research on the subject. This study is aimed at identifying how GUD can use lean manufacturing implementation to improve productivity, thereby ensuring maximum benefit and sustainability.

This chapter provided an overview of the research project and the motivation for this study. The focus of this study and the problem statement were also covered. The research question and the research objectives were then presented. An overview of the research methodology and the outline of the research were also summarised.

The next chapter is a synthesis and evaluation of different literature sources to gain a detailed understanding of lean. The literature review provides comparisons for the current study being conducted.

CHAPTER 2

An investigation into lean manufacturing implementation to enhance productivity

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2.1 Introduction

Whilst comparing the input to output ratios of companies in the international automotive industry, John Krafcik was credited with anointing companies with low ratios as 'lean', as it appeared they were "doing more with less" (Womack, Jones & Roos, 1990:13). This comparison was part of a study done by the MIT, benchmarking the differences between Western and Japanese automobile manufacturing under the International Motor Vehicle Program. But what is 'lean'?

Interpreting 'lean' is not simple even with 20 years of research and more than 50 years since its foundation (Pettersen, 2009). According to the Asian Productivity Organisation (APO) (2017:1), the Toyota Production System (TPS), often called Lean Production System, refers to the philosophy and tools of Lean Manufacturing or Lean Production. Anvari *et al.* (2011) observed that Lean manufacturing and Lean production are often known simply as 'lean'.

This literature review introduces the concept of lean by looking at the definition and origins of lean. The role of lean implementation in productivity improvement is then discussed. This is followed by an examination of the lean tools used to improve productivity. An overview of the different lean implementation processes is followed by an assessment of the reasons for lean implementation failures, including the role of employee involvement. The chapter concludes by reviewing the success factors for implementing lean.

2.2 Definition of lean

Shah and Ward (2007:4) observed that there is no common definition of the concept of lean but researchers generally describe lean from two main viewpoints, either the underlying philosophy of waste elimination, or from the practical application of tools and techniques.

In order to demonstrate the differing definitions available, a summary was compiled of the descriptions from numerous sources. The summary was done in the form of tables based on the main concept identified. These tables are:

Table 2.1 Definitions of Toyota Production System;

Table 2.2 Definitions of Lean;

Table 2.3 Definitions of Lean Thinking;

Table 2.4 Definitions of Lean Production and Lean Manufacturing

Table 2.1: Definitions of Toyota Production System

Concept	Definition / Quotation	Themes	Source
TPS	"The Four Rules that make up the DNA of Toyota" **1.** "All work shall be highly specified as to content, sequence, timing, and outcome." **2.** "Every customer supplier connection must be direct, and there must be an unambiguous yes-or-no way to send requests and receive responses." **3.** "The pathway for every product and service must be simple and direct." **4.** "Any improvement must be made in accordance with the scientific method, under the guidance of a teacher, at the lowest possible level in the organization"	Waste Elimination / Employee Empowerment	(Spear and Bowen, 1999:4)
TPS	"In the Toyota Way, it's the people who bring the system to life: working, communicating, resolving issues, and growing together"	Employee Empowerment	(Liker, 2004:36)
TPS or Lean Manufacturing or Just-in-time (JIT)	"The production system perfected by Toyota called just-in-time (JIT), or, alternatively, the TPS, today also known as lean manufacturing."	Waste Elimination	(Schonberger, 2007:404)
TPS or Lean	(1) "reducing the time for manufacturing processes by standardizing practices and" (2) "also maximizing value by eliminating, as much as possible, the waste of both material and human resources." Eventually, (3) "empowered employees participated regularly in small-group strategic planning sessions (Kaizen events) to further streamline processes and reduce waste"	Waste Elimination	(Brockberg, 2008:2)
TPS or Lean Manufacturing or LM or Lean Production or Lean	"is a production practice that considers the expenditure of resources for any goal other than the creation of value for the end customer to be wasteful and thus a target for elimination; basically, more value with less work. LM is a generic process management philosophy derived originally from the TPS" . . .	Waste Elimination	(Anvari, Ismail and Hojjati, 2011:1585)
TPS or Lean Manufacturing or Lean Production or Lean	. . . "is the systematic elimination of all types of waste" . . . "implementation of the concepts of continuous flow and customer satisfaction, through a flexible production system that allows for flexibility and rapid customization."	Waste Elimination	(APO, 2017:1)
TPS	"A production system which is steeped in the philosophy of *the complete elimination of all waste* imbuing all aspects of production in pursuit of the most efficient methods."	Waste Elimination	(Toyota, 2017:1)

(Source: Compiled by Author)

The elimination of waste appears 13 times as a theme amongst the 22 definitions summarised in the different tables. Even though the main concept discussed varies, the elimination of waste is a common theme. Toyota (2017) asserted that waste can be found in different forms and all these forms of waste tend to intertwine with each other ultimately spreading to creating more waste.

The spread of lean in recent times has been driven by recession and the removal of waste without the consumption of additional resources has made lean the choice for many companies (Jaiprakash & Kuldip, 2014). Lean is defined in Table 2.2.

Table 2.2: Definition of lean

Concept	Definition/Quotation	Themes	Source
Lean	"Lean can be considered in the broadest sense to be a philosophy, which aims to develop good practice of process or operations improvement that allows a reduction of waste, improvement of flow and better concept of customer and process view through a culture of continuous improvement involving everyone"	Waste Elimination / Employee Empowerment	(Radnor, Walley, Stephens and Bucci, 2006:85)
Lean	"Lean was originally developed to focus on eliminating waste and inefficiency in order to reduce costs, improve reliability and achieve better quality"	Waste Elimination	(Corbett, 2007:95)
Lean	"organizations regard lean merely as a set of tools and techniques without considering either the underlying conditions and principles or regard lean as a philosophy"	Five principles of Lean	(Radnor and Walley, 2008:13)
Lean	"There are many views of what constitutes lean" . . . "most people recognize its roots in the TPS" . . . "there has been considerable development of the concept over time" . . . "the five core principles of Lean, developed by Womack and Jones (1996)" . . . are . . . "Value, Value Stream, Flow, Pull and Perfection."	Five principles of Lean	(Radnor, 2010:412)
Lean	"is based on the central tenet that organizations will secure efficiency and quality advantages by stripping out wasteful processes."	Waste Elimination	(Carter, Danford, 2011:116)
Lean	"Originating from the Toyota Motor Corporation, lean is considered to be a radical alternative to the traditional method of mass production and batching principles for optimal efficiency, quality, speed and cost" . . . "it is not easy to define lean; the core to the lean philosophy is to continually improve a process by removing non-value added steps" . . .	Waste Elimination	(Radnor, 2011:1)
Lean	"five principles of lean" . . . "most widely cited in the academic literature" … "through understanding these principles and tying them all together, organizations can stay on course towards lean operations."	Five principles of Lean	(Burgess, 2012:26)
Lean	"The core idea is to maximize customer value while minimizing waste. Simply, lean means creating more value for customers with fewer resources."	Waste Elimination	(Lean Enterprise Institute, 2017:1)

(Source: Compiled by Author)

The term 'lean' appears most often in more recent publications and is used to describe the entire lean philosophy. According to the Lean Enterprise Institute (2017)

> "Lean means creating more value for customers with fewer resources; the core idea is to maximize customer value while minimizing waste."

Moving away from lean, 'Lean Thinking' summarised in Table 2.3 focuses on five principles which are discussed under lean implementation processes. One common theme in the definition is the transferability of lean, beyond automotive production, using the five principles.

Table 2.3: Definition of Lean Thinking

Concept	Definition/Quotation	Themes	Source
Lean Thinking	"Lean production methods were pioneered by Toyota" . . . "Lean thinking distils the essence of the lean approach into 5 key principles (Value, Value Stream, Flow, Pull and Perfection) and shows how the concepts can be extended beyond automotive production"	Five principles of Lean	(Hines, Found, Griffiths and Harrison, 2008:4)
Lean Thinking	"different operating paradigm in use by Toyota" . . . "referred to as lean production" . . . "five lean principles were identified to guide organizations in lean transformation" . . . "Value, Value Stream, Flow, Pull and Perfection"	Five principles of Lean	(Piercy and Rich, 2009:55)
Lean Thinking	"understanding of lean as a holistic manufacturing system. This system thinking stressed the strategic alignment of all elements of the production system to better meet customer demand. Eventually, the strategic essence of lean thinking" . . . "was extracted and it was argued" . . . "Lean core principles can be adapted to the specific circumstances of different organizations and industries"	Five principles of Lean	(Langer, 2011:6)

(Source: Compiled by Author)

Other terms like 'Lean Production' and 'Lean Manufacturing', summarised in Table 2.4, are used interchangeably by some researchers. Lean Manufacturing definitions focus on waste elimination; whilst Lean Production definitions focus on application of tools. Shah and Ward (2007) attempted to "address the confusion and inconsistency associated with Lean Production" and "clarify the semantic confusion surrounding Lean Production" whilst Jaiprakash and Kuldip (2014) described a "spurt" of Lean Manufacturing research and a "plethora" of Lean Manufacturing definitions.

Table 2.4: Definitions of Lean Production and Lean Manufacturing

Concept	Definition/Quotation	Themes	Source
Lean Manufacturing	"Lean production uses half the human effort in the factory, half the manufacturing space, half the investment in tools, half the engineering hours to develop a new product in half the time. It requires keeping half the needed inventory, results in many fewer defects, and produces a greater and ever growing variety of products"	Waste Elimination	(Womack, Jones and Roos, 1990:13)
Lean Production	"Lean production is a multi-dimensional approach that encompasses a wide variety of management practices, including just in time, quality systems, work teams, cellular manufacturing, supplier management, etc. in an integrated system."	Application of Tools	(Shah and Ward, 2003:2)
Lean Production	"Lean production is an integrated socio-technical system whose main objective is to eliminate waste by concurrently reducing or minimizing supplier, customer, and internal variability."	Socio-Technical System	(Shah and Ward, 2007:10)
Lean Production	"Although the score is not perfect, lean seems to be a reasonably consistent concept comprising just in time practices, resource reduction, improvement strategies, defects control, standardization and scientific management techniques" . . . "it is hard to formulate a clear definition that captures all the elements of lean and integrates the various goals"...	Application of Tools	(Pettersen, 2009:133)
Lean Manufacturing	"A common thread, however, is that it pertains to the removal of waste or non-value adding activities during the fabrication of a product or the delivery of a service"	Waste Elimination	(Smith, 2011:9)

(Source: Compiled by Author)

Taking into account the various definitions, Shah and Ward (2003) stated that lean combines different methodologies to produce high quality finished goods based on customer demand. This is in keeping with Schonberger's (2007) observation that the lean concept was introduced as shop floor practices, tools and techniques for higher efficiency. Both definitions refer to the lean tools although Shah and Ward claimed that the target is high quality finished goods, and Schonberger identified the target as efficiency.

In contrast, Anvari *et al*. (2011) described lean as a practice that views the use of resources for activities that do not create end user value as waste and these activities should therefore be eliminated. Smith (2011) also concluded that lean pertains to the removal of waste or non-value adding activities. These descriptions of lean recognise the underlying goal of eliminating waste.

A third type of definition is also evident, for example the APO (2017) defines the TPS in terms of interaction between people and systems, involvement of customers and suppliers, and elimination of waste as a focus.

Extrapolating from the tables of definitions presented, it can be summarised that lean is a *system* which *empowers employees* to use *various tools and techniques* in order to *continuously eliminate waste*, by understanding what the *customer values*. To fully understand the system known today as 'lean' requires some insight into the origins of lean.

2.3 Origins of lean

Lean was originally developed to focus on eliminating waste and inefficiency in order to reduce costs, improve reliability and achieve better quality. Toyota invented lean and much of their success comes from perfecting these tools and practices (Corbett, 2007).

This view is also supported by the APO (2017) when acknowledging that the chief architects of lean were Sakichi Toyoda, Kiichiro Toyoda, and Taiichi Ohno, and lean was only introduced to the west in the 1980s when Toyota's success was benchmarked by MIT researchers.

Although the term 'lean' was first used at MIT in the late 1980s, the concept of Lean Manufacturing evolved from various sources. According to Schlichting (2009), Henry Ford changed from craft manufacture to mass production in 1913. Typically, in craft production, skilled workers worked together to build cars by hand and parts would often need to be modified to work together. This made craft production very expensive as it required considerable time and effort.

In contrast, mass production produced standardised products made by workers, on single-purpose machines, in very high volume. One of the key characteristics of mass production was creating material flow and the use of moving conveyor belts to bring the cars to the workers.

This creation of flow was identified by the Lean Enterprise Institute (2017) as one of the five founding principles of lean. The downside of mass production was the increased costs associated with capital equipment, inventory and changeovers.

Langer (2011) summarised a comparison of the different types of production methods that is presented in Table 2.5.

Table 2.5: Comparison of production methods

		Craft Production pre-industrial revolution	Mass Production post-industrial revolution	Lean Production Japan: after WW2, Western world: after 1990
Description		"High variety, customised output with one skilled worker responsible for an entire unit of output"	"High volume of standardised output; capitalises on division of labour, specialised equipment, inter-changeable parts and assembly lines"	"Moderate to high volume with more variety; fewer mass buffers such as extra workers, inventory or time; smaller more flexible equipment"
Examples of goods and services		Past: All crafts and trades; Now: artist	Automobiles, computers, machinery	Automobiles, computers, machinery
Dimensions	Focus	Task (internal)	Product (internal)	Customer (External)
	Operations	Single units	Economic order quantity (EOQ), batch processing	End to end process; one piece flow; customer driven
	Aim	Expert craftsman	Lower cost, improve efficiency	Increase customer value by reducing waste
	Quality	Integrated (part of craftsmanship)	Separate from worker; inspection at the end of the production line	Prevention through staff empowerment; built in by product and process design
	Business strategy	Customer specific	Automate, Use large scale to get economy	Economies of flow & flexibility
	Improvement	Skilled / master knowledge used for CI	Expert knowledge, periodic improvement	"Workforce- and process-driven conti-nuous improvem"
Advantages		Customer specific design	Low unit cost; low-skill level employees	"Volume and product flexibility; variety; high quality of goods"
Disadvantages		"Slow, requires skilled workers; high costs and low standardi-sation"	"Inflexible regarding changes in volume, product or process design; low quality"	"Vulnerable to disrupt-tions (no buffers); more worker stress"

Adapted from Langer, T., 2011. *The Application of Lean thinking.* MSc Management. Queens University, Belfast.

Although Toyota is credited with the invention of lean as it is known today, many researchers argue that the TPS comprises thinking that goes as far back as the 1800s (Lean Enterprise Institute, 2017). Amongst others, Henry Ford, Fredrick Taylor, Frank Gilbreth and Lillian Gilbreth are credited with contributions to the TPS. Contributors to the development of the tools and methodology that form part of the TPS or lean are summarised in Table 2.6.

Although most academic articles on lean focus on the tools and methodology that were developed at Toyota, other researchers include developments outside of Toyota that have been adopted to support the TPS. For example, quality as a key element of a management system was developed in Japan by Edwards Deming and Joseph Juran in the 1950s. Tools like statistical quality control and the “Plan-Do-Check-Act” cycle were incorporated into the TPS, culminating in Toyota winning the Deming prize for excellence in quality in 1965 (Lean Enterprise Institute, 2017; Strategos, 2017).

Table 2.6: Contributors to the development of TPS

Year	Contributor	Description of Development	Source
1799	Eli Whitney	Interchangeable Parts	(Smith, 2011; Strategos, 2017)
1890	Frederick W Taylor	Standardised Work Time Study Work Standards Scientific Management	(Jones and George, 2009; Strategos, 2017)
1890	Frank Gilbreth	Process Charts Motion Study	(Jones and George, 2009; Strategos, 2017)
1890	Lillian Gilbreth	Motivation of Workers Impact of attitudes on the outcome of a process	(Jones and George, 2009; Strategos, 2017)
1867-1930	Sakichi Toyoda	Weft-breakage automatic stopping device (1896) Automatic loom with a non-stop shuttle-change motion (1924)	(Toyota, 2017)
1894-1952	Kiichiro Toyoda	Flow production method using a chain conveyor in textile plant (1927) Flow production method using a chain conveyor at Toyota (1938)	(Toyota, 2017)
1912 - 1990	Taiichi Ohno	Helped establish the TPS Basic framework for the Just-in-Time method Devised the seven wastes	(Ohno, 1978:1; Jones and George, 2009; Toyota, 2017)
1913 - Present	Eiji Toyoda	Implementation of jidoka and the Just-in-Time Empower Employees Standardise practices and reduce manufacturing times "Maximise value by eliminating the waste of both material and human resources." "Put together the TPS and enabled Toyota to compete head-on with companies in Europe and the U.S."	(Brockberg, 2008; Toyota, 2017)
1913	Henry Ford	Assembly Lines; Flow Production	(Jones and George, 2009)
1969	Shigeo Shingo	Single Minute Exchange of Dies Techniques of analysis and improvement of the operational activities in factories "Contributor to the fundamental concepts of TPS, such as Just in time, and the "pull" production system Poka-yoke (mistake-proofing)" Document the TPS	(Strategos, 2017)
1988	John Krafcik	Coined the phrase "Lean" in an article titled "Triumph of the Lean Production System"	(Strategos, 2017)
1990	Womack, Jones, and Roos	Wrote the book called "The Machine That Changed The World". Introduced the term "Lean Manufacturing" to the world.	(Lean Enterprise Institute, 2017)

(Source: Compiled by Author)

Adapted from Strategos (2017), Figure 2.1 summarises some additional contributors in a lean timeline. This timeline includes contributions by Edwards Deming and Joseph Juran, and also shows some of the key historic events that shaped the world. Just-in-time (JIT) is also identified in Figure 2.1 and this is part of Toyota's lean operations.

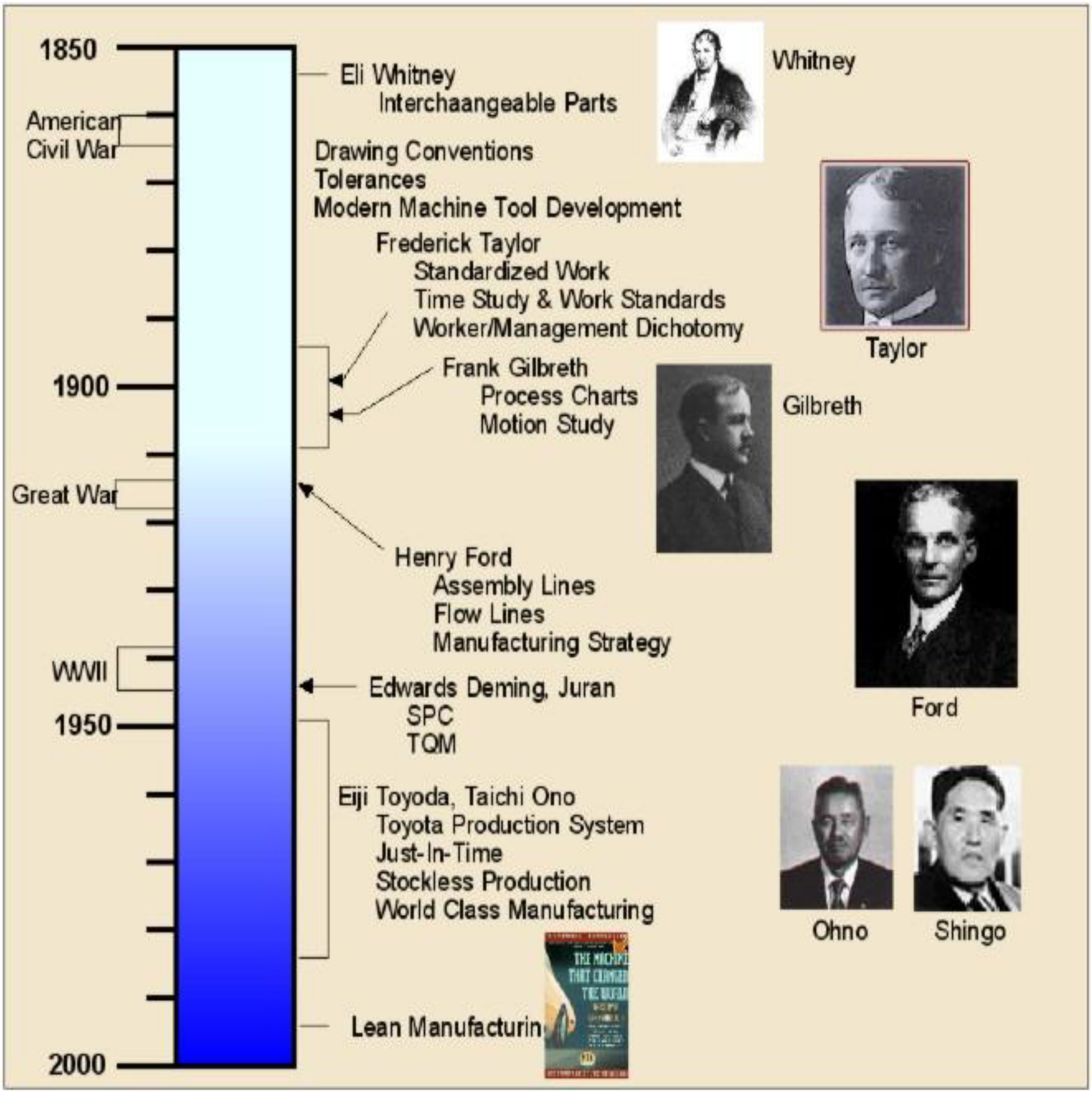


Figure 2.1: The lean timeline

Adapted from Strategos. 2017. *Lean Manufacturing Historic Timeline*. Strategos, Inc

2.4 Lean operations

Global competition, more demanding consumers and the need to use resources more effectively have placed pricing and financial pressures on organisations. As organisations seek to become more competitive, productivity becomes a requisite if a business is to meet the goals and objectives of its stakeholders. By improving productivity, an organisation can reduce costs and increase profits (Stevenson, 2015:5). To get a better understanding of productivity, one needs to start with the transformation process.

2.4.1 The transformation process

The production function of a business is responsible for using systems or processes to manufacture goods or services (Stevenson, 2015). The manufacturing of goods involves converting input into outputs using transformation processes. The inputs may be in the form of raw materials, labour or investment and the output can be in the form of finished products or inventory. The transformation process adds value to the inputs to create the outputs. The value-add is the difference between the input and output. Figure 2.2 replicates the conversion system discussed.

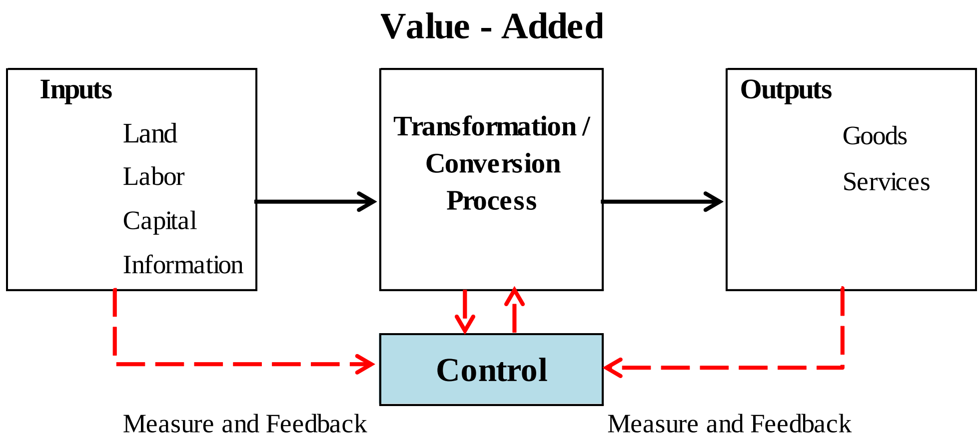


Figure 2.1: The transformation process

Adapted from Stevenson, W.J., 2015, *Operations Management*. 12th edn. New York, McGraw-Hill

A control system is used to measure the transformation process so that results can be compared to the expected outputs. By doing this, a company can take corrective actions if necessary in order to ensure that the desired outputs are achieved. This control loop is implemented because the company needs to make productive use of the resources available (Stevenson, 2015). The productive use of resources introduces the concept of 'productivity'.

2.4.2 Definition of productivity

The term 'productivity' is used to describe how well the company makes use of the resources available (Stevenson, 2015). Reid and Sanders (2011:43) described productivity as "a measure of how efficiently and organisation converts inputs into outputs".

These measures are used for labour planning, production planning, financial investigation and other activities. An important use of this measure is determining the competitiveness of a company by comparing with productivity measures of other companies. Generally, higher productivity is equated to lower cost (Reid & Sanders, 2011). There are several ways to measure productivity.

2.4.3 Measuring productivity

Productivity is measured as the "rate of output per unit input" (Stevenson, 2015). This is a ratio that can represent productivity of a company, a manufacturing department or an individual machine or operation. Table 2.7 summarises the different types of productivity measures.

Table 2.7: Productivity measures

	Description	Formula	Example
Partial Productivity	Based on a single input like Labour hours consumed	$\frac{\text{Output}}{\text{Input}}$	$\frac{\text{10 Bags}}{\text{10 Labour Hours}}$ = 1 bag per labour hour
Multifactor Productivity	Based on more than one input like Labour and Overheads consumed	$\frac{\text{Output}}{\text{Labour + Overheads}}$	$\frac{\text{10 Bags}}{\text{R10 + R10}}$ = 0.5 Bags per Rand
Total Productivity	Based on all inputs	$\frac{\text{Total Output}}{\text{Total Input}}$	$\frac{\text{10 Bags}}{\text{R 100}}$ = 0.1 Bags per Rand

Adapted from Reid, D.R. and Sanders N.R., 2011, *Operations Management.* 4^{th} edn. John Wiley and Sons, Inc

Partial, multifactor and total productivity measures are chosen based on what the company wants to achieve by the measurement. Measuring labour for example may help managers understand the impact of a change. Comparing the labour hours per unit before and after a change will give an indication of how effective the change was (Reid & Sanders, 2011). By measuring and monitoring different productivity ratios, a company can identify the factors that affect productivity.

2.4.4 Factors that affect productivity

There are various factors that can affect productivity. These can influence outcomes to increase or decrease productivity. Some of these factors may be controllable and some may not be controllable. Table 2.8 lists and describes some of the factors that influence productivity.

Table 2.8: Factors that affect productivity

Factor	Description
Methods	The methodology used to convert input into outputs
Capital	The investment in plant and equipment
Quality	The ability to meet customer expectations
Technology	The use of computers, internet and mobile technology for example
Management	The style, motivation, knowledge, skills etc
Standardisation	Standardise operations to reduce variation
Searching	Trying to in tools, inventory, etc wastes time
Rejects	Making products that cannot be sold
New employees	They can be less productive when they are new to the company
Safety	A safe working environment is a productive working environment
Skills shortage	If the current workforce does not have computing skills for example
Retrenchments	Reducing the workforce will result in short term gains
Labor Turnover	Losing skills and have to employ new people
Ergonomics	Designing the work area to be comfortable for the worker
Incentives	Rewarding good performance
Equipment Condition	Equipment breakdowns impact productivity
Reliability of supply	Shortage of materials will stop a production line

Adapted from Stevenson, W.J., 2015, *Operations Management*. 12th edn. New York, McGraw-Hill

The factors listed in Table 2.8 are by no means exhaustive, but simply highlight examples of variables that can impact on productivity. The most successful organisations strive to control these variables and continuously improve productivity.

2.4.5 Improving productivity

In order to remain competitive, companies employ different approaches to improve productivity and reduce costs. Stevenson (2015) suggested six key steps to help improve productivity:

1. Measure before you manage, so develop productivity measure for all operations.
2. Focus on the bottlenecks and improve the overall system to meet customer requirments.
3. Use cross-functional teams, benchmark other companies and involve employees.
4. Establish achievable goals for improvement.
5. Publicise management support for improvements and reward contributors.
6. Measure improvements and celebrate success.

There are several mechanisms for improving productivity. Table 2.9 summarises some of the different mechanisms available.

Table 2.9: Mechanisms for improving productivity

	1	2	3	4	5
Actions	O ↑ / I ↓	O ↑ / I →	O ↑ / I ↑	O → / I ↓	O ↓ / I ↓
Description	Increse Output and Decrease Input at the same time	Increase Output and keep Input constant	Big increase in ouput for a small increase in input	Keep Output constant and decrease intput	Small decrease in output for a greater decrease in input
Example	Increase production and reduce labour using new methods	Increase production using new methods with no additional input	Increase production with a small investment in new equipment	Achieve the same production output and reduce labour using new methods	A samll decrease in production with a massive reduction in labour

Adapted from Wang, C., 2004. *MGMT 280 - Issues in Productivity Management*. California State University.

The mechanisms in Table 2.9 basically vary inputs and outputs such that the end result is always an improvement in the productivity ratio. The direction of the arrows represents an increase, decrease or constant output (O) or input (I). The size of the arrow represents the magnitude of the increase or decrease in output and input.

When discussing inputs, the word ‘efficiency’ is very often used. Wang (2004) described efficiency as a measure of the expected resource consumption against the actual resources consumed. Likewise, when discussing outputs, the word ‘effectiveness’ is very often used. Effectiveness measures the planned output versus the actual output and can be measured as quality, quantity, on-time delivery, cost, etc. A company can boost its productivity by improving the efficiency and effectiveness of its processes as part of a strategy to become more competitive.

2.4.6 Productivity as a competitive strategy

Strategy is described as a plan for competing in the marketplace (Reid & Sanders, 2011). For a company to achieve results better than competitors, the company must have competitive advantage. Some authors use Porter’s generic competitive strategies to describe the three main strategies a company can adopt. A company can use low cost or differentiation to gain competitive advantage. Porter’s generic competitive strategies are replicated in Figure 2.3.

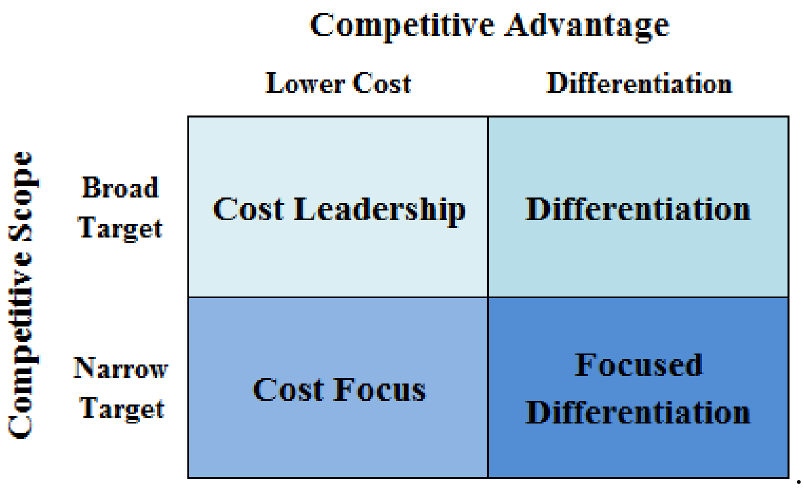


Figure 2.3: Porter’s generic competitive strategies

Adapted from Jones, G.J. and George, J.M., 2009, *Contemporary Management*. 6th edn. New York, McGraw-Hill

The 3 main strategies identified by porter can be summarised as follows:

1. Cost Leadership – The company will compete on price. Usually a ‘low cost producer’.
2. Differentiation – The company tries to be unique. Usually a premium brand.
3. Focus – Selecting a segment and competing in that segment on cost or differentiation.

A company that wants to adopt a low cost strategy, for example, will focus efforts on reducing costs and improving productivity. The test for any strategic approach is output versus input. Does the success justify the expenditure? Lean manufacturing is an approach to production that promises to deliver improved productivity (Coetzee *et al*., 2016) because lean offers a mechanism to achieve greater output with fewer inputs (Smith, 2011:1)

2.4.7 Lean implementation impact on productivity

The widespread interest in lean was triggered by the realisation that there were substantial productivity differences between Toyota and western car manufacturers. Toyota used the TPS to improve productivity, improve quality and reduce costs. This was achieved by eliminating waste and continuously improving everything. Numerous researchers (Liker, 2004; Radnor *et al.*, 2006; Hines *et al*., 2008; Radnor, 2010; Langer, 2011; Laureani, 2012; Lodgaard, Ingvaldsen, Gamme & Aschehoug, 2016; Coetzee *et al*., 2016) have recorded the benefits achieved by the implementation of lean. Although the benefits are recorded in different organisations, the impact on cost and productivity was mentioned by all these authors.

The reason for all referring to this impact is because companies implementing lean aim to continuously eliminate waste by identifying and removing non-value-adding activities (Liker, 2004; Smith, 2011), which has the effect of decreasing the inputs into the process. By reducing defects and removing variations that cause poor quality, companies can increase their output for the same or less input (Liker, 2004). It is therefore reasoned that successful lean implementation will result in increased productivity.

> *Shortening lead time by eliminating waste in each step of a process leads to best quality and lowest cost, while improving safety and morale* Liker (2004).

The benefits recorded by several researchers are summarised in Table 2.10 (Liker, 2004; Radnor *et al.*, 2006; Hines *et al.*, 2008; Radnor, 2010; Langer, 2011; Laureani, 2012;

Lodgaard *et al*., 2016; Coetzee *et al*., 2016). These benefits are separated according to their impact on inputs and outputs of the manufacturing process. The direction of the arrows indicates their impact on input and output. For example, reducing set-up time will lower inputs and reducing defects will increase outputs. Both improvements will contribute to improving labour productivity.

Table 2.10: Impact of lean implementation on input and output

Impact on Inputs		Impact on Outputs	
Set-up time reduction	↓	Continuous improvement	↑
Leveling production	↓	Failure prevention (Poka Yoke)	↑
Reduced raw material inventory	↓	Increased production output	↑
Reduced work in progress inventory	↓	Improved production flexibility	↑
Reduced finished product inventory	↓	Reduced complexity	↑
Decreased material usage	↓	Eliminating waste	↑
Decreased inputs, including energy	↓	Employee involvement / motivation	↑
Decreased physical infrastructure	↓	Problem-solving	↑
Optimized equipment - Capital Use	↓	Process measurement	↑
Reduced need for factory facilities	↓	Use data to manage performance	↑
Decrease waiting idle time	↓	Improve enterprise-wide performance	↑
Eliminate over-processing	↓	Reduced Defects	↑
Reduce over production	↓	Maximise utilisation of skills	↑
Reduce waste of motion	↓	Focus on the Customer	↑
Improve organisation	↓	Reduce cost of Quality	↑

(Source: Compiled by Author)

Lean implementation typically doubles labour productivity, cuts lead times and inventories by 90% and reduces defects, rejects and in-process inventories by 50% (Womack & Jones, 2003 cited in Langer, 2011). Similar results were recorded by Liker (2004), with 83% improvement in productivity, 83% reduction in work-in-progress inventory, 91% reduction in finished goods inventory and 46% reduction in lead times. At Toyota, these results were achieved by getting quality right the first time to improve productivity; in addition, cross-functional teams were also used to improve quality by focusing on what the customer values.

It can be stated that lean implementation improves the delivery of value to the customer by enhancing an organisation's core competencies (Smith, 2011). According to Radnor *et al.* (2006), lean application aims to drive process and operations improvement in order to reduce waste, improve workflow and provide a better understanding of processes and customer value, by making continuous improvement that engages everyone, a way of life.

Piercy and Rich (2009) claimed that lean can be implemented with small investments in developing people, and achieve significant productivity improvements in the short term. Research by Radnor *et al.* (2006) concurred that productivity gains can be achieved by implementing lean. These improvements are achieved by focusing on quality.

According to Liker (2004), Toyota discovered that focusing on quality actually reduced costs more than focusing on costs alone. In order to focus on quality and simultaneously reduce costs, Toyota developed several tools and improvement techniques that became collectively known at the TPS. The use of the TPS gained Toyota the reputation for being one of the most productive companies in the automotive industry. Some of the Japanese productivity improvement methods are discussed in the next section.

2.5 Japanese productivity improvement methods - Lean tools

Pettersen (2009) reviewed the lean tools frequently used to improve productivity and suggested a grouping for some of the frequently observed characteristics or features of lean. The lean tools were grouped into nine interdependent bundles, summarised in Table 2.11.

This section of the literature review aims to explain the tools identified by Pettersen (2009) in their respective bundles. These concepts can then be compared with tools and methodology used in lean implementations.

2.5.1 Just-in-time (JIT) practices

Just-in-time ‘aims to produce and deliver the right parts, in the right quantity, at the right time using the minimum necessary resources’ (Smalley, 2017:6), and consists of four essential parts (discussed below), namely production levelling, the pull system, processing using continuous flow and takt time (True Lean, 2017:1).

Table 2.11: Grouping of lean tools

Collective Term	Specific characteristics
Just in time practices	Continuous flow;
	Leveling Production (heijunka);
	Takted time
	Pull system (kanban);
Resource reduction	Small lot size;
	Eliminating Waste,
	Setup reduction,
	Reduce Lead Time & Inventory
Human relations management	Cross Training Employees;
	Involvement of Employees;
	Emphasise Teamwork
Improvement strategies	Quality circles;
	Kaizen - To Continuously Improve;
	Root cause problem solving
Defects control	Failure prevention (poka yoke);
	Autonomation (jidoka);
	100% inspection;
	Stop on error detection (andon)
Supply chain management	Value stream;
	Process Flows;
	Supplier Involvement
Standardization	Housekeeping (5S),
	Standardised work,
	Visual Control;
	Visual management
Scientific management	Time & work studies;
	Layout adjustments;
	Policy;
	Labor Reduction
Bundled techniques	SQC
	TPM
	Preventive Maintenance

Adapted from Pettersen, J. 2009. Defining lean production: some conceptual and practical issues. *TQM Journal*, 21(2), pp.127-142.

a) Production levelling (Heijunka)

Liker (2004) described levelling out the workload as principle number four of the 14 Toyota Way principles. The aim is to eliminate strain to people and to even out the production schedule. This involves the smoothing of production requirements over time by taking customer orders and sequencing them correctly (Smalley, 2017).

b) Pull system (Kanban)

The ‘pull system’ is where materials are drawn from preceding processes as they are required – this is an alternative to a 'push' system where materials are produced and passed on to the next process irrespective of whether it is required or not (Beyond Lean, 2017:4). Ohno (1978) described the Kanban as a ‘method for controlling inventory and work in progress, which generates the biggest waste in a factory’.

c) Continuous flow processing

Continuous flow processing is producing a product such that it flows from initiation to completion and to the customer with minimal stoppages, rework or reverse flows (Beyond Lean, 2017). This requires removing or minimising work in progress by using one-piece flow or a batch size of one (True Lean, 2017).

d) Takt time

Takt time is the time available to manufacture one unit at the rate customers require it, in other words the available processing time divided by the rate of customer demand (Beyond Lean, 2017).

2.5.2 Resource reduction

According to Womack *et al*. (1990), Krafcik originally used the term ‘lean’ in describing a production system that uses fewer resources than the traditional mass production philosophy. Pettersen (2009) identified resource reduction as one of the commonly observed characteristics of lean. Some of the tools and methods used to achieve reduction in resources consumed in a process are discussed below.

a) Small lot production

Small lot production is a prerequisite of the TPS as the TPS relies on taking what is needed when it is needed, and then replacing what is taken (Ohno, 1978). In order to achieve this, lots taken need to be small. If lots are large, the earlier process needs excess capacity to make the large amount.

b) Waste elimination

Waste elimination is the underlying philosophy of lean and waste must be removed from the entire production process (Shah & Ward, 2007; APO, 2017).

Ohno (1978) identified *seven kinds of waste*:

1. Transportation – Transporting parts to numerous locations.

2. Inventory – Keeping more parts than required.

3. Motion – Moving unnecessarily when doing the work.

4. Waiting or idle – Waiting for a previous step.

5. Over-processing – Processing a part more than required to meet customer needs

6. Over-production – Making more parts than you can sell.

7. Defects – Creating parts that do not meet customer standard.

c) Set-up time reduction

This is the reduction of the time it takes to switch over from the processing of one product to another (True Lean, 2017).

d) Lead time reduction

Lead time is the total time elapsed between placing an order and receipt of the product or service (Beyond Lean, 2017). One of the goals of the TPS is to shorten the time 'from the moment the customer places an order to the point where the cash is collected' (Ohno, 1978).

e) Inventory reduction

Inventory is all materials required in production and can also include consumable goods used in a process itself. One of the goals of lean practice is to continuously eliminate inventory when possible (Lean Enterprise Institute, 2017).

2.5.3 Human relations management

The TPS culture encourages, supports, and demands employee involvement.

> *TPS is a system designed to provide the tools for people to continually improve their work and means more dependence on people, not less* Liker (2004).

Although Pettersen (2009) identified team organisation, cross-training, and employee involvement as part of human relations management, Shah and Ward (2003) only placed ‘flexible cross-functional work force’, and ‘self-directed work teams’ in a bundle called human resource management.

a) Team organisation

According to Liker (2004), a company can use cross-functional teams to focus on continuous improvement, thereby enhancing quality, increasing productivity and improving flow. Companies also need to develop individuals so they are able to work in teams and achieve common goals.

b) Cross-training

Cross-training involves giving individuals the skill to perform a variety of tasks so that they can operate different equipment, vary their work content and even perform other types of work which they are not responsible for (Smalley, 2017).

c) Employee involvement

Employee involvement consists of training of employees and involving them in improvement initiatives in order to ensure sustainability through continuous instead of rapid improvement (Schlichting, 2009).

Although employee involvement is included as a characteristic in Petersen’s summary, this will be discussed in detail later in the chapter.

2.5.4 Improvement strategies

Improvement strategies consist of continuous small step improvements (Kaizen) and innovations. Kaizen strategies are used to continually improve work methods and innovation results in bigger improvements through investment in processes or capital resources (Beyond Lean, 2017).

a) Improvement circles

Although continuous improvement is driven by a management philosophy, it involves all employees, typically through quality circles that give adequate attention and feedback to employees about improvement suggestions (Smith, 2011).

b) Continuous improvement (Kaizen)

Kaizen is a continuous effort to find and remove the root causes of poor performance and are usually small step improvements (Beyond Lean, 2017).

> *Continuous improvement focuses on the elimination of waste, or non-value-added activities, throughout the organisation, and also attempts to alter processes for the purpose of adding value* (Smalley, 2017).

c) Root cause analysis (five why)

The root cause of quality problems must be found and then eliminated. To determine the root cause of a problem, teams are encouraged to ask "why" five times (True Lean, 2017).

2.5.5 Defects control

In traditional production methods the final product undergoes quality checks before it is released to the customer, but there is no guarantee that all products conform to requirements. In order to prevent defects being shipped to the customer, the TPS aims to build quality into the product (Smalley, 2017).

a) Autonomation (jidoka)

Autonomation is described as:

> *"A form of automation in which machinery automatically inspects each item after producing it, stopping production, and notifying humans if a defect is detected."* Beyond Lean (2017)

b) Failure prevention (poka yoke)

Poka yoke is used to build **"**fail-safes" into a process to prevent defects and ensure that any defect produced does not flow to processes downstream (Beyond Lean, 2017).

c) One-hundred-percent inspection

As one of the rules of the Kanban system, defective parts are not passed on to subsequent processes (Smalley, 2017). One-hundred-percent inspection is commonly used to avoid passing non-conforming parts to subsequent processes. Each of the items produced is measured and judged to be either conforming or non-conforming and the conforming items get passed along, whilst the non-conforming items get set aside for rework. (Wheeler, 2011:1)

d) Line stop (andon)

An andon is an indicator light or audible alarm triggered when an abnormal event occurs. It is a device used as part of visual management and managed by the line operators. This could be a breakdown, defective part, shortage of inventory, or if there is an error that needs correction (Beyond Lean, 2017).

2.5.6 Supply chain management

Liker (2004) identified respect for the total network of associated companies and suppliers; and treating suppliers as an extension of the business as one of the principles of the TPS.

a) Value stream mapping/flowcharting

Value stream mapping is a means of making work flow visible with the objective of improving communication and understanding. This tool is used to track the flow of the product from the customer (downstream) to the supplier, with the intention of identifying non-value-adding activities or waste (Smith, 2011).

b) Supplier involvement

This usually involves relationships with suppliers, whereby both organisations share knowledge openly, resolve any problems together and establish expectations from each other (Beyond Lean, 2017).

2.5.7 Standardisation

Standardisation is a prerequisite for both autonomation and JIT. In order to limit variation in a process and achieve efficiency, production methods must be consistent. Amongst the tools used to achieve standardisation are standardised work, 5S and visual control. These tools also help to identify and resolve problems (Smalley, 2017).

a) Housekeeping (5S)

A method of workplace organisation through standardised and visual controls is 5S. It is an acronym for the Japanese words which when translated mean sort, order, cleanliness, standardise, and discipline (Warwood *et al*, 2004 cited in Smith, 2011:29).

b) Standardised work

Standardised work is where all jobs are organised around ergonomics to create an efficient production system with no waste. Standardised work "is made up of three elements: takt time, working sequence and standard in-process stock" (True Lean, 2017).

c) Visual control and management

Visual control, also commonly known as management by sight, is a key component of lean. The intention is to make waste and even variation of any kind visible – thereby highlighting an abnormal condition (Smith, 2011).

2.5.8 Scientific management

This is an approach that emphasises the scientific study of work methods in order to improve process efficiency (Jones and George, 2009).

a) Policy deployment (hoshin kanri)

This is very similar to a strategic plan in that it specifies goals, targets and how these will be achieved in order to concentrate on business priorities; it is also a medium- to long-term plan and is developed by upper management (True Lean, 2017).

b) Time/work studies

Frederick W. Taylor, Frank and Lillian Gilbreth, and a number of other scientific management pioneers perfected work-study techniques that revolved around setting standard methods of work by conducting method and time studies, which in turn were used for job scheduling, supervision, and control (Jones & George, 2009).

c) Multi-manning

To manufacture using small batches and maximise resource utilisation, employees must be able to perform different functions and operate different equipment. Multi-manning refers to a situation where an operator mans more than one piece of equipment at the same time (True Lean, 2017).

d) Workforce reduction

A key ingredient of cellular manufacturing is that it caters for workforce flexibility. Workforce becomes the variable that gets adjusted as the demand fluctuates. This does not necessarily mean the staff are retrenched or rehired every time the demand fluctuates, but rather that staff are allocated to the product lines with increased demand, and reduced from the lines that have a drop in demand. Key to multi-manning of course is up-skilling of staff in multiple processes (Smith, 2011).

e) Layout adjustments

The arrangement of equipment and workstations is vital for ensuring the continuous flow of inventories and material. The traditional *batch and queue* approach, where similar processes or equipment are grouped together, meant that parts were transported to where they were to be processed. A layout adjustment to a leaner approach, often translates into a cellular layout (Smith, 2011).

f) Cellular manufacturing

Arrangement of equipment and workstations such that the layout facilitates the flow of products from one step to another in batch sizes as small as one piece. All equipment and workstations that are required to produce a part are located together in a ‘cell’ allowing timely feedback when problems occur (Smith, 2011; Beyond Lean, 2017).

2.5.9 Bundled techniques

The two bundled techniques identified are discussed below.

a) Statistical quality control (SQC)

SQC is the use of methods based on statistics to monitor and control a process, thereby ensuring good quality products (Render, Stair and Hanna, 2012:555). SQC therefore helps to eliminate waste and rework by using control charts to monitor a process in order to identify variation and the causes of variations are identified and eliminated (True Lean, 2017).

b) Total productive maintenance and preventive maintenance

Total productive maintenance is a strategy where operators are trained to perform certain maintenance activities including cleaning, minor adjustments, lubrication, and minor part changes (Beyond Lean, 2017).

Preventive maintenance is "advanced scheduling or calendar based activities relating to maintenance procedures. Preventive maintenance is performed irrespective of breakdown and before any failure" (Smith, 2011).

2.6 Lean tools and their appearance in key references

Pettersen's (2009) summary was compared to key literature reviewed and the results are summarised in Table 2.12. The highlighted rows indicate which tools appear in all the references summarised in the table. The table only indicates that the tools were used and is not indication of how successful the application was.

According to Pearce and Pons (2013:49), poor understanding of the objectives of existing lean tools has resulted in inferior application of these tools. This view is supported by Schlichting (2009) who found that the tools have a dependence on each other. Numerous sources refer to the "House of Lean" (Schlichting, 2009; Smalley, 2017; Coetzee *et al*., 2016) when discussing lean tools and their application. The "House of Lean" is meant to describe how all the tools fit together.

Table 2.12 Lean tools and their appearance in key references

	(Radnor et al., 2006)	(Shah and Ward, 2007)	(Hines et al., 2008)	(Brockberg, 2008)	(Pettersen, 2009)	(Schlichting, 2009)	(Radnor, 2010)	(Anvari, Ismail and Hojjati, 2011	(Smith, 2011)	(Lean Enterprise Institute, 2017)
Production leveling (heijunka)		x	x		x	x	x	x	x	x
Pull system (kanban)	x	x	x	x	x	x	x	x	x	x
Takted production	x	x	x		x	x	x	x	x	x
Continuous flow processing	x	x	x	x	x	x	x	x	x	x
Small lot production		x	x		x	x		x	x	x
Waste elimination	x	x	x	x	x	x	x	x	x	x
Setup time reduction		x	x	x	x	x		x	x	x
Lead time reduction	x	x	x	x	x	x	x	x	x	x
Inventory reduction	x	x	x	x	x	x	x	x	x	x
Team organization	x	x	x	x	x	x	x		x	x
Cross training / multi-skilling	x	x	x	x	x	x			x	x
Employee involvement	x	x	x	x	x	x	x	x	x	x
Improvement circles	x		x	x	x	x	x	x	x	x
Continuous improvement (kaizen)	x	x	x	x	x	x	x	x	x	x
Root cause analysis (5 why)	x		x		x	x	x		x	x
Autonomation (jidoka)		x	x		x	x	x	x	x	x
Failure prevention (poka yoke)		x	x		x	x	x	x	x	x
100% inspection	x	x	x		x	x	x	x	x	x
Line stop (andon)		x	x		x	x			x	x
Value stream mapping / flowcharting	x	x	x	x	x	x	x	x	x	x
Supplier involvement	x	x	x	x	x	x		x	x	x
Housekeeping (5S)	x		x	x	x	x	x		x	x
Standardized work	x		x	x	x	x	x	x	x	x
Visual control and management	x		x		x	x	x	x	x	x
Policy deployment (hoshin kanri)	x		x		x		x	x	x	x
Time / work studies	x	x	x		x	x	x	x	x	x
Multi manning					x	x			x	x
Work force reduction	x				x		x		x	x
Layout adjustments	x	x	x		x	x			x	x
Cellular manufacturing	x	x			x	x	x		x	x
Statistical quality control (SQC)	x	x	x	x	x			x	x	x
TPM / preventive maintenance		x	x		x	x		x	x	x

(Source: Compiled by Author)

2.7 The House of Lean

The Toyota Production System (TPS) is sometimes represented as the 'House of Lean' which is shown in Figure 2.4. The House of Lean, which consists of a foundation, pillars and roof, documents the major components of the TPS as well as the key methods and tools (Smalley, 2017).

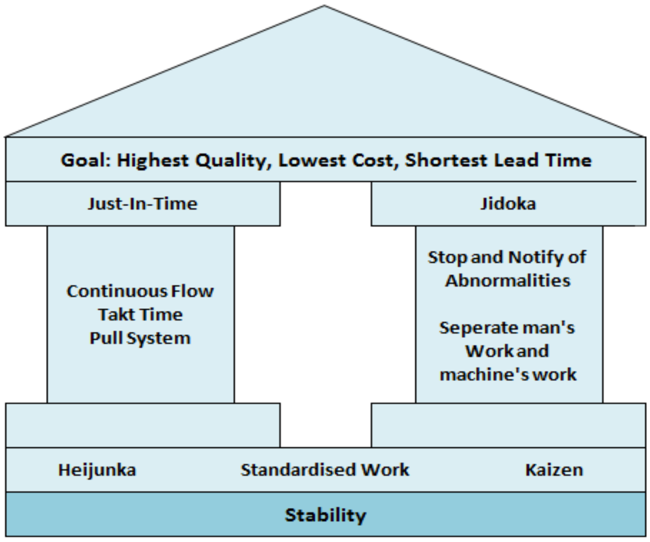


Figure 2.4 House of Lean

Adapted from Smalley, A., 2017. *Toyota Production System Basic Handbook.* Art of Lean, Inc.

According to Schlichting (2009), the diagram represents the dependence of the components on each other. The foundation is a platform of stability, and some representations show the base as inclusive of total productive maintenance and visual management as a prerequisite for operational stability. The two primary pillars consist of just-in-time to focus on waste reduction and jidoka which builds in quality; whilst the roof represents the overall goals of Toyota used to drive productivity improvement (Smalley, 2017).

Ignoring the 'House of Lean' and the dependence of components on each other, most lean articles discuss the tools on their own. This influences readers to believe the tools can be independently applied to solve problems or improve performance (Schlichting, 2009). This has resulted in a 'Reduced House of Lean' presented in Figure 2.5. The two primary pillars still consist of just-in-time and jidoka; whilst the roof represents the overall goal of waste elimination. Figure 2.5 summarises the lean implementation processes seen today.

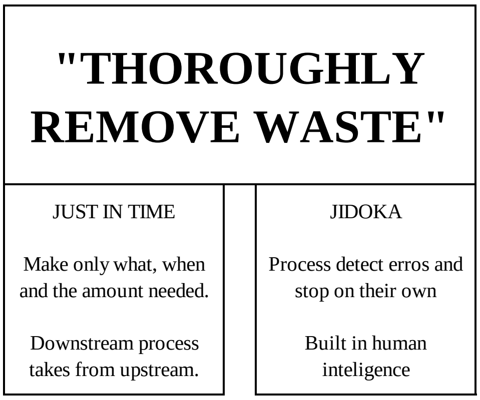


Figure 2.5 Reduced House of Lean

Adapted from Schlichting, C., 2009. *Sustaining Lean Improvements*. MSc Manufacturing Engineering. Worcester Polytechnic Institute.

2.8 Lean implementation processes

2.8.1 Lean thinking

Lean was originally described by Womack, Jones and Roos in their book 'The Machine That Changed the World'. In a second book, titled 'Lean Thinking', Womack and Jones broke lean down into five key principles which capture the essence of the lean approach (Lean Enterprise Institute, 2017). These five principles are summarised in Figure 2.6.

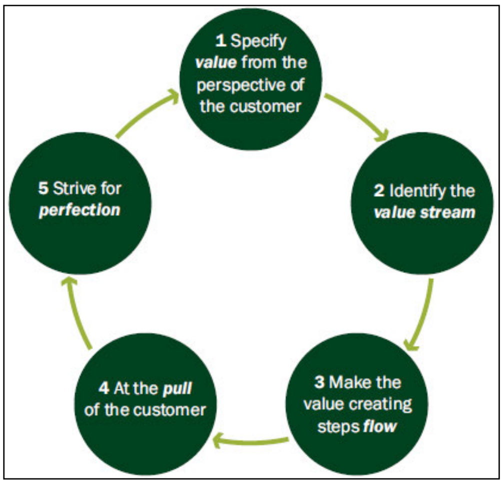


Figure 2.6 The five lean principles

Adapted from Hines, P., Found, P., Griffiths, G. and Harrison, R., 2008, Staying Lean: Thriving, Not Just Surviving. *Lean Enterprise Research Centre*. Cardiff University, Cardiff.

Principle 1 = Identify customers and specify value – The aim of lean is to provide value for the customer and this requires eliminating or minimising everything else (Hines *et al*., 2008). By understanding what the customers view as 'value', the waste can be identified (Schlichting, 2009).

Principle 2 = Identify and map the value stream – The value stream includes all activities, both value adding and non-value adding, required to produce an item, from product concept to delivery to the customer (Lean Enterprise Institute, 2017).

Principle 3 = Create flow by eliminating waste – In order to ensure that the product or service 'flows' to the customer without delays, all waste must be removed (Schlichting, 2009).

Principle 4 = Respond to customer pull – Goods or service should be produced based on customer demand (Hines *et al*., 2008).

Principle 5 = Pursue perfection –

> *Manage towards perfection so that the number of steps and the amount of time and information needed is continually reduced* (Radnor *et al*., 2006).

The authors described these principles being "a sort of North Star… a dependable guide to action to help managers transcend the day-to-day chaos of mass production" (Womack & Jones, 2003 cited in Burgess, 2012). According to Hines *et al*. (2008), these five key principles are essential to the removal of waste.

In support of this view, some authors (summarised in Table 2.3) have used these five principles as the definition of lean and recommend these principles be used as a guideline to implement lean. Langer (2011:6) found that "Lean core principles can be adapted to the specific circumstances of different organizations and industries".

In contrast, other researchers have also identified different approaches to implement lean, some of which are discussed next.

2.8.2 Approaches to implement lean

Pettersen (2009) identified four implementation processes used by organisations to implement lean that are summarised in Figure 2.7. These four implementation processes were further divided into Operational, Strategic, Philosophical and Practical.

Acknowledging the operation and practical dimensions of lean, are authors who define lean from the practical applications of tools and techniques (Shah & Ward, 2003; Schonberger, 2007; Radnor & Walley, 2008). In contrast, authors who define lean by the underlying philosophy of waste elimination refer to the strategic and philosophical approach to lean implementation (Emiliani, 2008; Anvari et al., 2011; Langer, 2011; Coetzee *et al.*, 2016).

	Operational	**Strategic**
Philosophical	2 Leanness	4 Lean Thinking
Practical	1 Toolbox Lean	3 Becoming Lean

Figure 2.7 Four definable lean implementation processes

Adapted from Pettersen, J. 2009. Defining lean production: some conceptual and practical issues. *TQM Journal*, vol. 21 no. 2, pp.127-142.

<u>Box 1 – Toolbox Lean</u>

Box 1 represents an implementation process where a lean toolbox is used by 'subject matter experts' to 'get things done' using isolated projects with defined start and end dates (Burgess, 2012). Emiliani (2008) very bluntly described the toolbox lean approach as "fake lean".

This type of lean implementation process is not unique, with various authors describing companies focusing on implementing lean tools in isolation, and warning that such implementations are flawed (Radnor *et al.*, 2006; Schonberger, 2007; Pearce & Pons, 2013; Coetzee *et al.*, 2016). These authors strongly recommended that employee involvement and customers focus must be part of the lean implementation process to ensure sustainability and to achieve the full benefits of lean implementation.

<u>Box 2 – Leanness</u>

Box 2 represents the application of tools in order to obtain a state of 'Leanness' by focusing on improvement projects (Pettersen, 2009). According to Burgess (2012) these organisations are not actually implementing lean, rather they are applying some of the tools to predefined problems.

Coetzee et al. (2016) also described this type of lean implementation under the heading "Prerequisites for a lean transition". Some of the typical characteristics described include having an enterprise vision, creating an awareness of the need for change, creating the need to achieve quick wins, empowering employees, teamwork and using a teacher as part of the process.

Another author who described this type of lean implementation is Liker (2004), although it was an innovation used as part of an organisation wide implementation. The same characteristics described by Liker (2004) are observed when researchers identified an implementation process known as "Kaizen Blitz". A Kaizen Blitz employs a small array of lean tools to realise quick improvements in problem areas. These projects focus on short-term, immediate problems with the aim of finding a solution and improving the current state. These projects are normally done as workshops and are facilitated by lean experts in order to achieve knowledge transfer (Radnor *et al.,* 2006; Langer, 2011).

Some of the advantages and disadvantages of this type of approach identified by Radnor *et al.* (2006) are summarised in Table 2.13.

Table 2.13 Advantages and disadvantages of the Leanness approach

Advantages	**Disadvantages**
Used to focus on tangible results	Does not impact all staff
Short-term results	Does not address all problems
Does not require change in management style	Not visible to everyone
Low investment required	Lack of sustainability
Short-term impact on quality	May not help to change culture
Lower resistance to change	Focus on short, simple projects

(Source: Compiled by Author)

Box 3 – Becoming Lean

This box represents a systems-focused implementation that aims to continuously improve and become lean (Burgess, 2012). Improvements are aimed at achieving some goal or performance target which is part of the continuous improvement effort.

Coetzee *et al*. (2016) described this type of lean implementation as production operational level transition to lean (TTL). This type of lean implementation process is used to launch the lean philosophy and best practices to the organisation. This implementation process is described as methodical, with defined goals that must be achieved in a specific order. This concept is summarised in Table 2.14.

Table 2.14 TTL Production Operation Level

Phase	**Description**	**Some Key Actions**
Phase 0	Adopt of a lean strategy	Create the vision, Define the need, Commit to change, Train people
Phase 1	Prepare implementation	Develop an implementation strategy, Establish target objectives
Phase 2	Identify customer value	Select initial implementation scope, Identify customer and value
Phase 3	Determine the value flow	Initial value stream, Establish baseline
Phase 4	Prodiction System Concept	New value stream, Plan new layout, Integrate suppliers
Phase 5	Implement flow	Standardise operations, eliminate / reduce waste, Cross-training
Phase 6	Implement pull system	Onee piece flow, production levelling, line balancing
Phase 7	Strive for perfection	Team development, Institute kaizen events, Evaluate against metrics

Adapted from Coetzee, R., van der Merwe, K. and van Dyk, L., 2016. Lean Implementation Strategies: How Are The Toyota Way Principles Addressed? *South African Journal of Industrial Engineering*, vol. 27, no. 3, pp. 79-91

Box 4 – Lean Thinking

This box denotes companies that entrench lean as ‘part of their daily work’ (Corbett, 2007). Pettersen (2009) described this approach as implementing “Lean Thinking” (citing the five principles of lean discussed earlier) or “The Toyota Way” (referring to the book written by Liker (2004) describing the TPS), which describes enterprise-wide lean implementations which forms part of a long-term strategy of the company.

Radnor et al. (2006) and Radnor and Walley (2008) also reported on an approach to lean implementation they called "full implementation" which forms part of a long-term strategy of the company. The full implementation model entails embedding lean principles, wider application of lean tools, aligning lean to business strategy by adopting a complete systems view and resembles the original implementation model at Toyota.

More recently, Coetzee *et al*. (2016) described this type of implementation as enterprise level 'TTL Roadmap' and indicated that this plan was formulated to help companies achieve lean transformation. This roadmap represents some general steps required to start, maintain and continuously improve an organisation using principles and best practices derived from lean. Table 2.15 summarises the enterprise level TTL as described by Coetzee *et al*. (2016).

Table 2.15 TTL Enterprise Level

Steps	**Some Key Actions**
1. Adopt a lean paradigm	Build vision, Convey urgency, Foster lean learning, Make the commitment
2. Focus on the value stream	Map the value stream, vision, goals & metrics, involve key stakeholders
3. Develop lean structures & behaviour	Organise for lean implementation, Empower change agents, Align incentives
4. Create & refine transformation plan	Prioritise activities, Commit resources, Education & training
5. Implement lean initiatives	Develop detailed plans, Implement lean activities
6. Focus on CI	Monitor lean progress, Nurture process, Refine the plan, Adopt new knowledge

Adapted from Coetzee, R., van der Merwe, K. and van Dyk, L., 2016. Lean Implementation Strategies: How Are The Toyota Way Principles Addressed? *South African Journal of Industrial Engineering*, vol. 27, no. 3, pp. 79-91

Some of the advantages and disadvantages of the lean thinking approach identified by Radnor *et al* (2006) are summarised in Table 2.16.

Table 2.16 Advantages and disadvantages of the lean thinking approach

Advantages	Disadvantages
A complete change in culture	Implementation presents a bigger challenge
High improvement potential	Longer to complete implementation
Suatainable changes	Longer lead time to realise results
Entire system changes	More potential for resistance
Can be linked with strategy	Requires a change in mamangement styles

Radnor, Z., Walley, P., Stephens, A. & Bucci, G. 2006. *Evaluation of the Lean Approach to Business Management and It's Use in the Public Sector*. Scottish Executive Social Research, Edinburgh

Like Emiliani (2008), other researchers (Radnor and Walley, 2008; Burgess, 2012; Coetzee *et al*., 2016) conceded that organisations have different approaches to implement lean. These researchers further acknowledged that the two main types of lean implementation can be described by a focus on lean tools (for cost reduction) or a focus on 'Lean Thinking' (to improve customer satisfaction). Emiliani (2008) very bluntly described the toolbox lean approach as "fake lean" which is most likely to fail and the 'Lean Thinking' approach as "real lean", which is most likely to succeed.

2.9 Reasons for lean implementation failures

Schlichting (2009) gathered data on the reasons for lean implementation failures from 32 websites found using Google search. The frequency of appearance of these categories was summarised in a spreadsheet and graphed to provide an indication of the distribution of the reasons. Schlicting's data is summarised in Figure 2.8.

The most often featured reasons are lack of employee involvement (34%), missing management support (19%), stable operations (16%) and rapid lean implementation (16%). These findings can be validated in the literature reviewed.

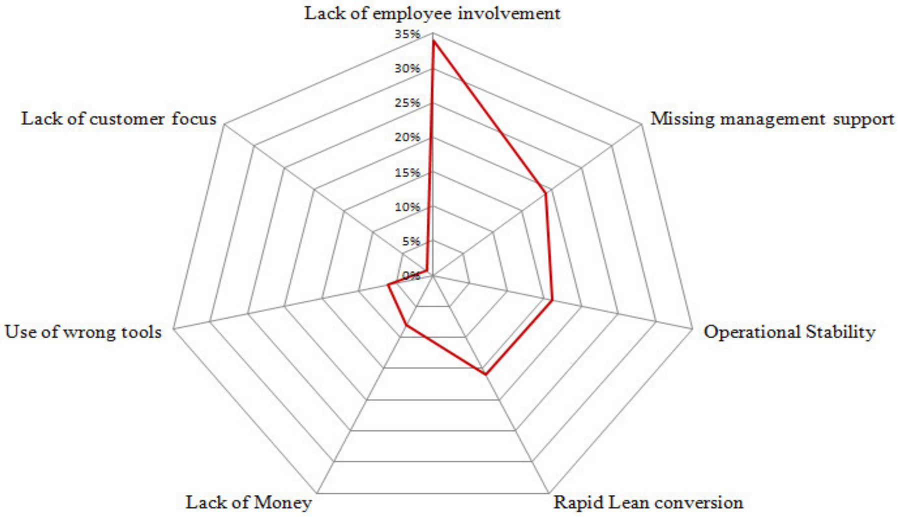


Figure 2.8 Summary graph for failure categories

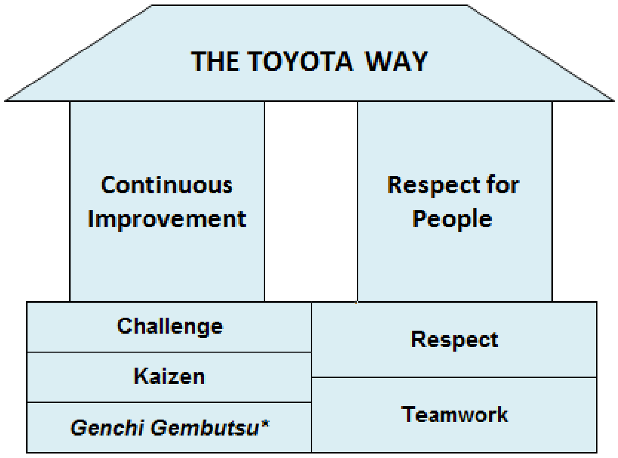
Adapted from Schlichting, C., 2009. *Sustaining Lean Improvements*. MSc Manufacturing Engineering. Worcester Polytechnic Institute.

The top four categories identified by Schlichting are discussed further.

2.9.1 Employee involvement

Radnor and Walley (2008) asserted that embedding a culture that encourages employee involvement in an organisation is a prerequisite for the implementation of lean. Employee involvement is synonymous with the term "respect for people". Emiliani (2008) referred to implementations as 'real lean', and described a system of management where 'respect for people' is crucial. This view is supported by various researchers including Liker (2004) and more recently by Coetzee *et al*. (2016:81) who argued that TPS is not a toolbox, but a system that encourages people to continually improve all aspects of their daily work. These researchers further declared that "people are the centre of the TPS house".

Coetzee *et al*. (2016) used "The Toyota Way" model to explain the reliance of people in TPS and this is replicated in Figure 2.9. This depiction is very similar to the 'house of lean' (Figure 2.4) discussed earlier in relation to lean tools. Figure 2.9 is meant to represent how teamwork and respect form a major part of respect for people. By asking an employee to contribute to solving a problem, respect is shown. Teamwork is used to help people develop and to maximise performance.



*Genchi Gembutsu is Japanese term for go and see for yourself.

Figure 2.9 The Toyota Way Model

Adapted from Coetzee, R., van der Merwe, K. and van Dyk, L., 2016. Lean Implementation Strategies: How Are The Toyota Way Principles Addressed? *South African Journal of Industrial Engineering*, vol. 27, no. 3, pp. 79-91

Supporting this view are other researchers like Shah and Ward (2003) and Pettersen (2009) who included team organisation and employee involvement as part of the characteristics of lean tools being implemented. Table 2.17 lists various lean tools discussed earlier that have an element of teamwork and employee involvement. Pettersen (2009) even included employee involvement as a characteristic observed. These tools very closely resemble the ‘respect for people’ and ‘continuous improvement’ pillars shown in Figure 2.9. Burgess (2012) additionally noted tools that allow an employee to stop the production line when defects are detected, as an indication of how important an employee is to the TPS.

Table 2.17 Employee involvement in lean

Collective Term	Specific Characteristics
Human relations management	Team organisation
	Cross training
	Employee involvement
Improvement strategies	Improvement circles
	Continuous improvement (kaizen)
	Root cause analysis (5 why)

(Source: Compiled by Author)

Also recognising the importance of employee involvement, Hines (2012) noted that the success of lean implementation will depend on most of the employees believing it will work. These employees need to see the benefits for themselves and the company, and need to be motivated to continually improve. This is achieved by engagement of people in the lean journey, making sure that company policies, reward systems, recognition systems, succession planning and communications are aligned with the vision and mission (Hines *et al*., 2008).

In summary, most researchers agree that the involvement of employees in the lean implementation process has a big influence on the success of implementation. Coetzee *et al*. (2016:80) stated:

> *It can thus be said that the success of a lean transformation lies substantially in the hands of the employees who are responsible for implementing the change.*

2.9.2 Management support

Womack and Jones (1996) described three types of leaders required to transform an organisation:

1. An experienced worker, with a long history, to provide stability and continuity.
2. A specialist with expert lean knowledge.
3. Someone to be the leader and remove organisational barriers.

Holweg (2007:428) submitted that many managers found it difficult to implement a lean approach and the reason for this was the different management approaches required for lean and traditional mass production. Others found that management do not see lean as a strategic approach, but rather as a set of tools to improve shop floor performance (Corbett, 2007; Kovacheva, 2013; Emiliani, 2013).

Liker and Hoseus (2010:34) argued that the reason for this was rooted in the differences between a traditional western leader and a Toyota leader. The traits of the different leaders are summarised in Table 2.18. A key difference that is evident from this comparison is that the Western leader is ambitious and results driven, focusing on the numbers. In contrast, the

Toyota leader is process driven, develops people and seeks to continuously learn. These differences essentially impact on the culture created within the organisation and contribute to lean failures.

Table 2.18 Traditional Western leader compared to TPS leadership

Western Leadership	TPS Leadership
Expects short-term results	Patience
Proud	Humility
Moving up the ranks quickly	Seeks to understand over time and slow progression
Must achieve outcomes at all cost	The correct process will deliver the required results
Reaches goals through people	Advances peoples' knowledge and skills
Gets around obstacles	Fully understands problem and establishs the root cause before solving the problem
Numbers-driven management style	Seeks to understand the process

Adapted from Liker, J.K. and Hoseus, M., 2010. Human Resource development in Toyota culture. *Int. J. Human Resources Development and Management*, 10(1), pp.34–50.

2.9.3 Operational stability

Operational stability refers to the foundation of the House of Lean (Figure 2.4), which includes tools that are applied to create a foundation for lean (Schlichting, 2009). Liker and Hoseus (2010) also described the foundation of lean as being stable and repeatable processes whilst Kovacheva (2013) described as a stable system with less variation as a prerequisite. To achieve this, Schlichting (2009) proposed using standardised work and smoothing demand in order to achieve stability. Liker (2004) asserted that the process must first be stabilised before CI tools can be used in problem solving.

> *Use stable, repeatable methods everywhere to maintain the predictability, regular timing, and regular output of your processes. It is the foundation for flow and pull*
> Liker (2004:154).

This is in keeping with Womack *et al*. (1990), Corbett (2007) and Emiliani (2013) who argued that the tools are dependent on each other for the most success.

2.9.4 Rapid lean conversion

Rapid lean conversion refers to the short time span that companies require in order to change things around. Schlichting (2009) identified that companies are expecting a return of investment of between six and 24 months.

> *A real lean conversion involves multiple cycles of continuous improvement which will not be accomplished in such a short time frame* (Schlichting, 2009).

This short-term view is in keeping with the toolbox implementation processes described previously. Liker (2004); Langer (2011) and Coetzee *et al*. (2016) all described implementations that focus on short-term, immediate problems, normally done as workshops, and facilitated by lean experts.

This is in direct contrast with the principle of Kaizen, which involves continuous small step improvements, usually over the long term (Liker, 2004). A more long-term view must be considered if a lean implementation is to be successful.

2.10. Success factors for implementing lean

Hines *et al*. (2008) developed the 'Sustainable Iceberg Model' to describe the features of lean implementation. The sustainable iceberg model is depicted in Figure 2.10.

As described by Hines (2012:1):

> *The model depicts two 'above the water' features that are generally visible in successful lean transformations: Technology, Tools & Techniques and Processes as well as three 'below the water' features of Strategy & Alignment, Leadership and Behaviour & Engagement. These 'below the water' features are usually invisible in successful lean transformations but are the basis of embedding lean and creating a sustainable lean transformation.*

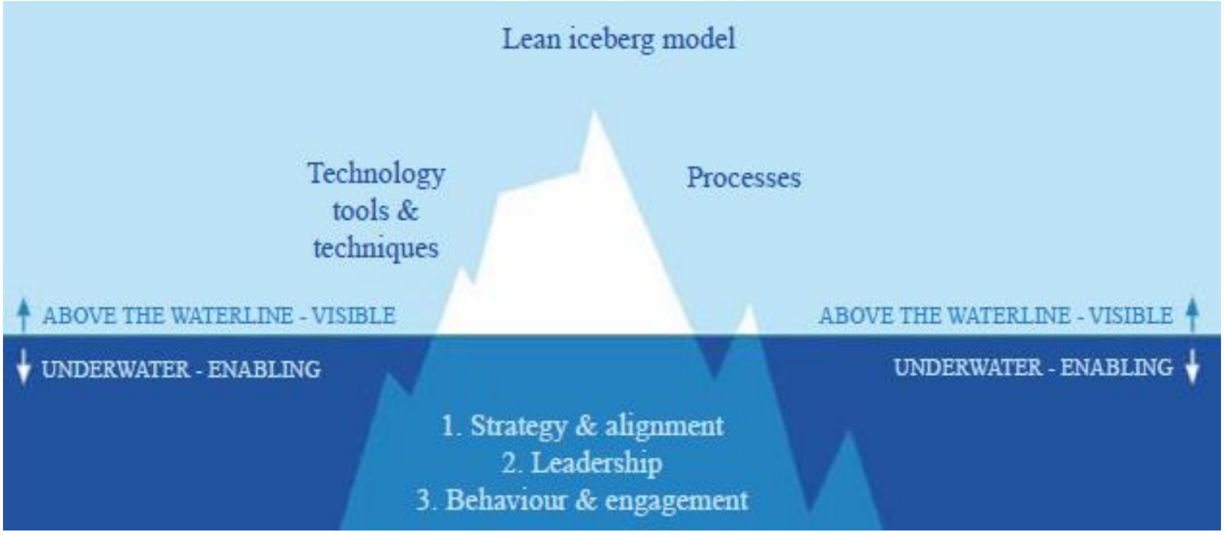


Figure 2.10 The 'Sustainable Iceberg Model'

Adapted from Hines, P., Found, P., Griffiths, G. and Harrison, R., 2008, Staying Lean: Thriving, Not Just Surviving. *Lean Enterprise Research Centre*. Cardiff University, Cardiff.

2.10.1 Technology, tools and techniques

Most lean literature focuses on the skills, tools and techniques. Many implementations therefore focus on the tools instead of the customer needs, the strategic business requirements and employee needs (Hines *et al*., 2008). Lean should be based on three main doctrines:

- Remove anything the customer defines as waste.
- Smooth out the demand for products.
- Simplify the process for the worker.

2.10.2 Processes

According to Hines (2012), many organisations have around 30% inefficiency, created by their management systems and structures. Companies fail to define customers and understand customer needs, even if these companies adopt a lean approach.

2.10.3 Strategy and alignment

Many organisations fail to establish a strategy, vision and mission that are communicated to everyone in the organisation (Hines, 2012). They need to establish what needs to be achieved, the importance of these goals and must provide direction to staff.

An important component is to have some key metrics for the business. These would be at the different strategic levels (Hines, 2012).

2.10.4 Leadership

Hines (2012:5) stated:

> *Many organizations possess good managers but not necessarily good leaders. Leaders are usually characterized as having a guiding vision, passion and integrity. They have high energy levels, are innovative, focus on people, inspire trust, have a long range perspective and challenge the status quo.*

2.10.5 Behaviour and engagement (Employee Involvement)

The ability for an organisation to move its people to constantly challenge and drive continuous improvement, should speak to the fact that the lean journey is more than the implementation of tools; instead it speaks of people being given the scope to identify opportunities for improvement by constantly challenging the current way of doing things (Radnor & Walley, 2008). This view is supported by various researchers discussed previously.

2.11 The Lean Transformation Model as a Conceptual Framework

The Lean Enterprise Institute (LEI) was founded by Jim Womack and disseminates lean thinking and practice to help organisations adopt lean. After years of observation and working with various companies, the LEI developed a lean transformation model to help companies achieve successful lean transformation. The lean transformation model is replicated in Figure 2.11.

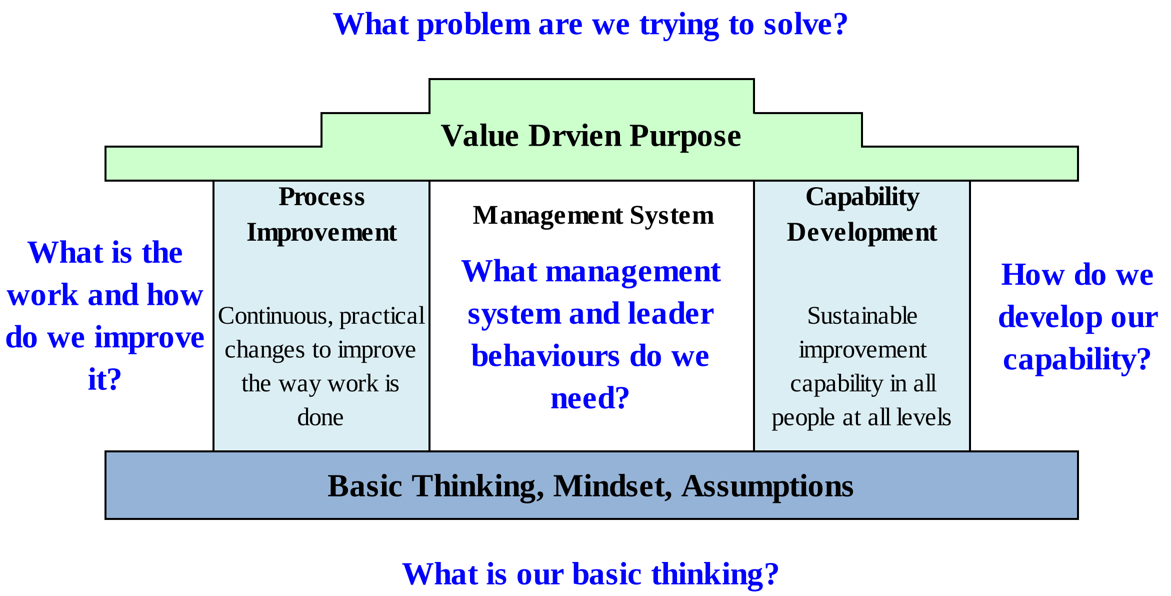


Figure 2.11 The Lean Transformation Model

Adapted from the Lean Enterprise Institute, 2017. *The Lean Transformation Model*. Available at: http://www.lean.org.

The lean transformation model is represented as a house. The roof is the value driven purpose which is supported by the walls which are process improvement and capability development. The content of the house is made up of the management systems and the foundation is the basic thinking and mindset of the business. All of these elements come together to create a successful lean transformation.

The transformation model consists of a series of questions that are used to determine the company's approach to lean transformation.

Question 1 – What problem are we trying to solve? – Leads to the target condition.

Question 2 – What is the work and how do we improve it? – Establishes what needs to be improved to get there.

Question 3 – How do we develop our capability? – Determines how we develop people to achieve the improvements.

Question 4 – What management system and leadership behaviours do we need?

Question 5 – What basic thinking will drive the transformation? – What thinking style do we need?

Using this model as the conceptual framework for the current research, the new model that was designed is replicated in Figure 2.12.

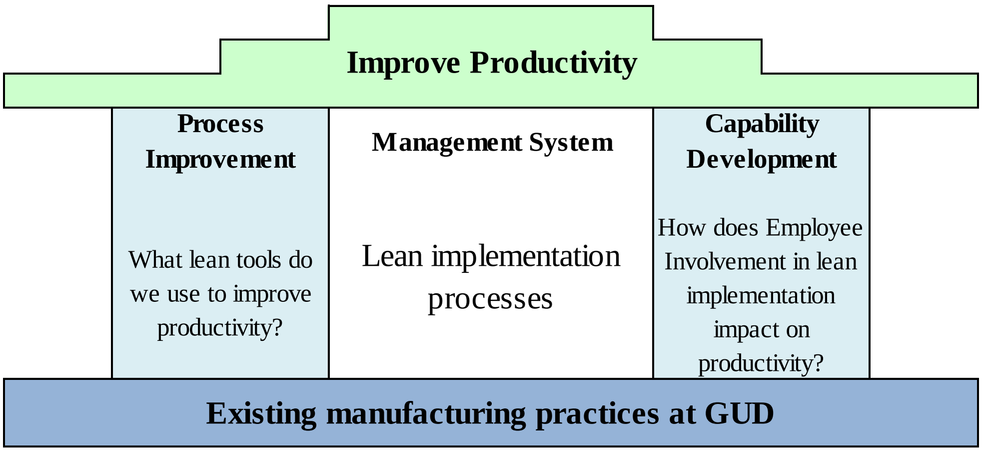


Figure 2.12 The Conceptual Framework

Question 1 – What problem are we trying to solve? – To improve productivity by implementing lean manufacturing.

Question 2 – What is the work and how do we improve it? – What lean tools can be used to improve productivity?

Question 3 – How do we develop our capability? – How does employee involvement in lean implementation impact on productivity?

Question 4 – What management system and leadership behaviours do we need? – What lean manufacturing implementation processes impact on productivity improvement?

Question 5 – What basic thinking will drive the transformation – What are the existing manufacturing practices at GUD?

According to LEI (2017), the different parts of the system need to work together to achieve lean success. The conceptual framework shown in Figure 2.12 shows how the various results sought by the research may contribute to improving productivity.

2.12 Chapter summary

The term lean was first used by MIT researchers to describe companies that appeared to be doing more with less. Understanding lean is not straightforward despite many years of research on the subject. This chapter introduced lean and discussed the various definitions of lean. This was followed by a comparison of the different production methods to describe how production evolved over time.

Although Toyota is credited with inventing lean, other contributors to the development of lean were also identified. After exploring the history of lean, lean operations and productivity were discussed. Frequently used lean tools were grouped into nine interdependent bundles and each of these tools was discussed further. In addition, different lean implementations processes applied in manufacturing were discussed. The chapter concluded with a discussion on the reasons for lean implementation failures and success factors for implementing lean.

While it is evident from the discussion in this chapter that there are different implementation processes used to implement lean and many lean tools available to improve productivity, there is no guideline on which model to use, and which tool combination to select, in order to improve productivity. To determine this, additional research is required and the next chapter presents the methodology for such research.

CHAPTER 3

Research methodology

3.1 Introduction

The previous chapter presented the literature review on lean and identified different lean implementation processes and tools available to improve productivity. Further research is required to determine the implementation model used and which tools have had an impact on productivity at GUD.

The purpose of this chapter is to provide a thorough examination of the research methodology, and a justification for the approach and methods used in this study. This chapter details the aim of the study, research design and the research process adopted, and elaborates on the data collection and data analysis methods employed. The last section of this chapter explores the ethical approach to the research.

3.2 Aim of the study

According to Saunders, Lewis and Thornhill (2009), the aim of the research must be documented at the start as this will guide the entire process. The research starts with the research idea, and this leads to the research question which embodies the aim of the study. Stated in simple terms, the aim of the study describes what the study sets out to achieve and the objectives are specific statements used to describe outcomes that can be measured.

The problem statement was discussed in Chapter 1 and relates to GUD implementing lean as a toolbox. Researchers have found that selecting specific lean tools to implement without understanding the entire lean system limits the improvement in productivity achieved and eventually leads to frustration.

In contrast, some researchers have advocated customisation and tool selection for productivity improvement. Researchers also identified one of the reasons for lean failure to be a focus on lean tools and not on employee involvement. This view is supported by other researchers who found that that the lean journey is more than the implementation of tools. At GUD, the lean toolbox is only used by a few skilled individuals in manufacturing, with little employee involvement.

This study aims to look at the factors that affect implementation of lean manufacturing to improve productivity.

3.3 Participants and location of the study

One of the factors to consider when embarking on a research project is where one could possibly gain access and to develop a topic that will match the type of access granted (Saunders *et al*., 2009). The request to carry out a study may entail gaining access to a range of participants based on the target population that has been defined. In order to meet the objectives of the study, the location and participants of the study need to be carefully selected.

This study was conducted at the GUD factory based in Prospecton, Durban. Founded in 1949, GUD is an automotive filter manufacturer. The company supplies filters to the South African aftermarket, overseas export markets and local car manufacturers. GUD Prospecton factory was chosen for the study based on convenience and ease of access to the site, because the researcher is based at this facility.

The participants of the study were limited to employees in the production assembly areas at GUD Prospecton factory. This included employees in production support functions like engineering services, production engineering, quality engineering, and stores. The rationale for this selection was that lean had not been introduced to non-manufacturing areas of the factory, like the finance department. In addition, all persons involved in the original design of the lean initiative at GUD were included in the study.

3.4 Overview of the research design

The process followed in this research design is described by Saunders *et al*. (2009) as the 'research onion', shown in Figure 3.1. The layers represent the steps involved in the research design process. Figure 3.1 has been limited to philosophies and strategies that have been described by other authors.

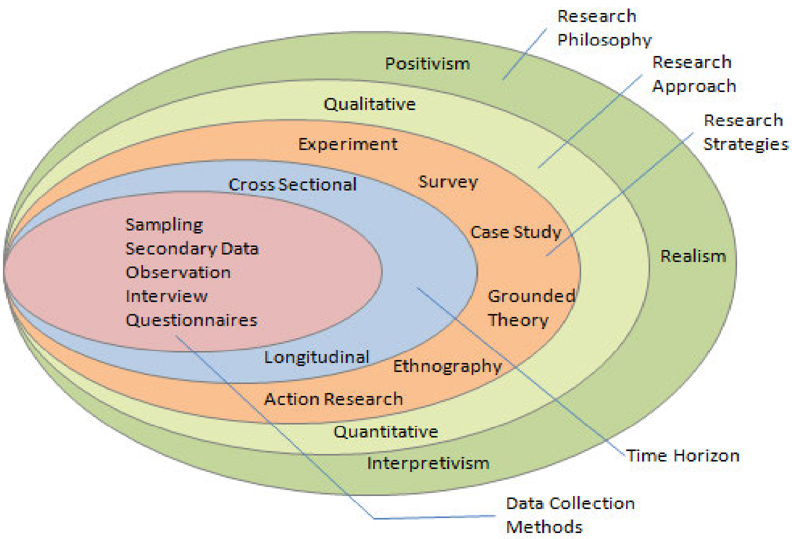


Figure 3.1: The 'Research Onion'

Adapted from Saunders, M., Lewis, P., Thornhill, A., 2009. Research Methods for Business Students. 5th ed. Harlow: Pearson Education.

3.4.1 Research philosophy

A research philosophy is a way of thinking about and conducting research, which guides the researcher. It is also the starting point in research design (Collis & Hussey, 2014). When undertaking research, it is important to consider all research philosophies since these factors describe insight, belief, speculation and the nature of reality and truth (Flowers, 2009).

Collis and Hussey (2014) listed two main philosophical positions:

- Positivism – Stresses attention to actual practice over consideration of what is ideal.
- Interpretivism – Social reality is subjective because it is influenced by our perceptions.

The main research philosophy chosen for this research was the positivist research philosophy. The strength of the positivist approach is that it can provide a wide coverage, is fast and economical.

Interpretivism was used as a philosophy when collecting some data. Interviews were conducted to identify the reasons for lean implementation at GUD and the expectations of the lean implementation.

3.4.2 Research approach

The two main research approaches shown in Figure 3.1 are quantitative and qualitative. Anderson (2009) defined quantitative as "the term given to data that can be quantified and counted" and qualitative as "the term given to data that is based on meanings which are expressed through words and language".

According to Johnson and Christensen (2012), quantitative research is used primarily for description, explanation, and prediction, results are statistical and the goal is to 'generalise' the results.

> *Qualitative research is used primarily for the purposes of description and exploration and to gain an understanding of how people think and experience their lives* (Johnson and Christensen, 2012).

Mixed methods

Many researchers argue that there is value in both quantitative data and qualitative data (Anderson, 2009). Research that uses both quantitative data and qualitative data is described as "mixed-methods research" (Saunders *et al*., 2009). Mixed-methods research is being favoured by more contributors on the subject (Saunders *et al*., 2009; Anderson, 2009).

This study made use of mixed methods research. Qualitative data collection in the form of a structured interview was used to collect data from the team that introduced lean at GUD and quantitative data collection in the form of a survey was used to collect data from all other participants.

3.4.3 Research strategy

Saunders *et al*. (2009) described several research strategies. These are summarised in Figure 3.1, as experiment, survey, case study, action research, grounded theory and ethnography. These are described below.

- Experiment – Testing different assumptions by trial and error under conditions constructed and controlled.
- Survey – A data collection instrument used to carry out research. A large number of people are asked the same set of questions.

- Case study – Investigates a phenomenon within its real-life context.
- Grounded theory – The discovery of theory from data.
- Action research – Learning by doing.

The research strategy adopted for this research was using surveys to collect data. A survey methodology is "designed to collect primary or secondary data from a sample", with a view to "analysing them statistically and generalising the result to a population" (Collis & Hussey, 2014). The survey is a non-experimental, descriptive research method.

A sample of respondents were selected from GUD Prospecton site and asked a standardised set of questions. The survey comprised a document that had to be completed by the person being surveyed. A face-to-face interview or telephone interview was used for some participants.

Various authors have described the strengths of the survey method, listed in Table 3.1, and the weaknesses of the survey method, listed in Table 3.2 (Anderson, 2009; Saunders *et al*., 2009; Collis & Hussey, 2014).

Table 3.1: Strengths of the survey method

1	Suveys are inexpensive because they can be self-administered.
2	Very large samples are feasible using surveys. This makes the results statistically significant.
3	Administering the survey is flexible as it can be delivered using different methods.
4	Standardising the survey allows similar data to be collected from multiple sources. This allows comparison between sources.
5	Surveys can be used to describe the characteristics of a population.
6	Many questions can be asked about a subject allowing flexibility in the analysis.
7	Standardised questions ensures all participants have the same understanding, making analysis more accurate.
8	Subjectivity of the observer is greatly reduced because all subjects have a standard survey. This ensures reliability of results.

(Source: Compiled by Author)

Table 3.2: Weaknesses of the survey method

1	Standardisation may force the researcher to develop questions that will be appropriate for all respondents, possibly missing out what is appropriate for many respondents.
2	A large number of the selected sample is required.
3	Survey research (excluding some interview approaches) can seldom deal with "context" .
4	The assumption is that the participants remeber the information and will answer truthfully when faced with a controversial question.
5	Surveys are inflexible in that the survey cannot change throughout the data collection.

(Source: Compiled by Author)

3.4.4 Time horizon

There are two types of surveys described below:

Cross-sectional surveys

These surveys are used to gather data at a single point in time (Sekaran & Bougie, 2016).

Longitudinal surveys

These surveys are used to gather data over a longer time period (Sekaran & Bougie, 2016).

A cross-sectional study was conducted at GUD Prospecton factory.

3.4.5 Data collection methods

Saunders *et al.* (2009) listed the following data collection methods: sampling, secondary data, observation, interview, questionnaires. These are described in Table 3.3. Data can be collected using one or more of these methods.

Secondary data for this research included department reports, company presentations and performance measurement data that are available within GUD. The use of this data was governed by the permission granted by GUD.

Table 3.3: Description of different data collection methods

Sampling	Selecting a small group from a bigger group The bigger group is called the population Findings are based on the sample Use evidence and reason to make a conclusion Cheap and Fast
Secondary Data	The data is already available and researcher can access it Previous research data; state studies Can focus the research on specific areas Primary data is gathered at the source Primary data can be used to select secondary data
Observation	Recording data from watching people or things People in the sample agree to be observed Non-participant - Does not want to be observed Requires a longer time span
Interview	Structured interview or unstructured interview Interviewers must be trained Interviewer records interview Accurate recording of interview required Complex data analysis Requires a longer time span
Questionnaires	Predetermined questions are written Participants select answer Alternative answers are provided for selection

Adapted from Saunders, M., Lewis, P., Thornhill, A., 2009. Research Methods for Business Students. 5th Ed. Harlow: Pearson Education .

Anderson (2009) described several issues that contribute to the data collection methods chosen. These are discussed below.

- The type of topic – Research questions; data required to answer the questions; how can that data be obtained?
- The amount of literature available – Use methods that can be used to build on existing knowledge.
- Timelines – Some methods have a longer time span than others.
- Resources – Availability of special resources if required.
- Permission granted and access – Methods may be prescribed by project sponsors.

After some key considerations related to timescale, resources available and permission granted by GUD, the data collection methods used for this research were sampling, structured interviews and questionnaires.

3.5 Research process

Collis and Hussey (2014) defined methodology as "an approach to the process of the research, encompassing the body of methods". A summary of the research process proposed by Saunders *et al.* (2009) is shown in Figure 3.2. This research commenced with the formulation of the research topic and review of the current literature on the topic. Choosing the research philosophy was followed by formulating the research design. Next, permission was sought from GUD and ethical clearance was obtained from the University Ethics Committee.

Data collection for the study was the next step, using the mixed methods approach, and this was followed by data analysis. The final step in the research process was writing of the report and revision. Both the planning process and the revision process are also shown in Figure 3.2.

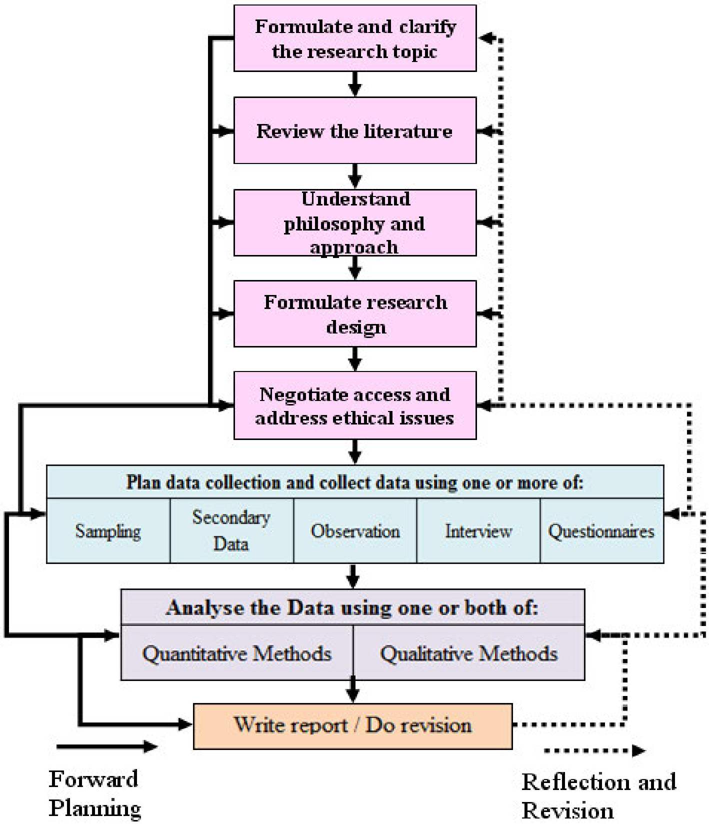


Figure 3.2: The research process

Adapted from Saunders, M., Lewis, P., Thornhill, A., 2009. Research Methods for Business Students. 5th Ed. Harlow: Pearson Education.

3.6 Sample size

It is usually too expensive and time consuming to question everyone (population). So only some of the individuals (elements) are selected. The selection (sample) should represent the larger group (Sekaran & Bougie, 2016). The difference between a population, sample and element is illustrated in Figure 3.3.

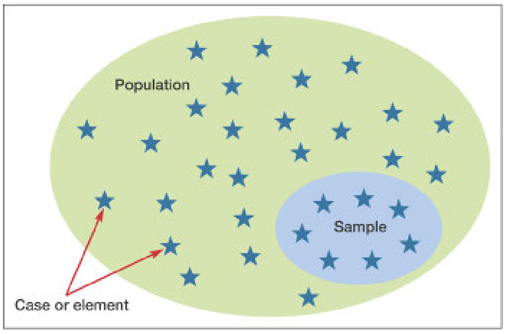


Figure 3.3: Population, sample and individual cases

Adapted from Saunders, M., Lewis, P., Thornhill, A., 2009. Research Methods for Business Students. 5th Ed. Harlow: Pearson Education .

Designing the sample requires three decisions:

Who will be surveyed? (*The sample)* – The knowledge that will be gained from the study and who is most likely to possess this information.

How many people will be surveyed? (*Sample size*) – The larger the sample size, the more reliable the outcomes will be.

How should the sample be chosen? (*Sampling)* – Choose the sample *at random* from the entire population (*probability sample*). The selection may be based on ease of access to members (*non-probability sample*).

3.6.1 Probability sample

Simple random sample: There is an equal chance of selecting any member of the population.

Stratified random sample: Random samples are taken from the population that is already divided into groups such as height groups.

Cluster (area) sample: Random samples are taken from the population that is already divided into groups such as residential area.

3.6.2 Non-probability sample

Convenience sample: The sample is obtained by selecting the easiest population members.
Judgement sample: Judgement is used to select a sample where the best information will be provided.
Quota sample: The researcher uses a quota to determine the number of people to survey.

A cross-sectional study with a sample of 132 was conducted at GUD Prospecton site in the month of October 2017. Table 3.4 summarises the population that was considered for this research. The population was divided into several departments.

Table 3.4: Summary of the population for the study

Department	Number of Staff
Seam on Assembly (SOA)	110
EFI / Metal Free	30
Multiport	16
Production and Quality Engineering	13
Engineering Services	15
Technical	5
Management	9
	198

According to The Research Advisors (2006), to ensure that the research has a confidence level of 95% and a margin of error of 5%, requires a sample size of 131, when the population is 198. This quota of 131 was used as the target number for this study when collecting data. Participants were chosen randomly based on their availability to complete the survey. Where the number of staff is low; the target was to try to ensure that all staff completed the survey.

All persons involved in the team that introduced lean at GUD were interviewed using a structured interview. The quality of the data was an important consideration in this research.

3.7 Criteria for effective data: Data quality

Credibility is an important consideration is any research. This can be described as the degree to which the data that has been collected is both relevant and valuable (Anderson, 2009). To make this assessment it is essential to consider the quality of the data and the way in which the study has been undertaken. Anderson (2009) described two concepts:

Reliability – Extent to which similar results would be achieved if the study is repeated.
Validity – Does the data really provide evidence about the subject matter?

Table 3.5 summarises reliability, validity and generalisability in quantitative research and qualitative research. Researchers (Anderson, 2009; Saunders *et al.*, 2009; Sekaran & Bougie, 2016) have asserted that the reliability and validity of measures used must be established.

Table 3.5: Reliability, validity and generalisability

	Quantitative Research	**Qualitative Research**
Validity	Does the instrument do what it is supposed to do (measure)?	Has the researchr gathered all the knowledge required from the participant?
Reliability	Are the results repeatable (assuming no change in conditions)?	Are the results repeatable if another person did the obsrvations (assuming no change in conditions)?
Generalisability	Can the findings for the sample be generalised for the population?	Can the findings be generalised?

Adapted from Anderson, V., 2009. Research Methods in Human Resource Management. 2nd Ed. Chartered Institute of Personnel and Development.

Saunders *et al.* (2009) described four threats to reliability which are discussed below.

3.7.1 Subject or participant error

In order to minimise participant error, the questionnaire for team members was designed to be as simple as possible. GUD uses questionnaires for training evaluation and employee surveys, so the questionnaire developed for this research used similar scales for ease of understanding.

The questionnaire also included closed-ended questions, multiple choice questions or scale questions to simplify the responses. The survey was also administered during a team meeting where all participants could complete the questionnaire simultaneously with the researcher present to answer any queries.

The survey was administered in English with people who speak both English and Zulu present in order to translate instructions and queries.

3.7.2 Subject or participant bias

As a manager in the company, the author has a higher level of authority than most of the respondents and this could have influenced the respondents' openness and honesty. This is a threat to the reliability of the research. To overcome this, confidentiality and anonymity were emphasised throughout the research process. Employees were reassured that the author will not disclose their identity at any stage.

3.7.3 Observer error

To reduce observer error, the interview with the team that introduced lean at GUD was done in writing with the permission of the participant and was undertaken by the author. All questionnaires were also administered by the author.

3.7.4 Observer bias

The author was aware of the fact that his own mindset could create bias and that the results of the research might highlight aspects of departmental performance. This threat to reliability was reduced by using closed-ended questions and basing the questionnaire on information obtained from the literature review.

3.8 Data collection instruments

3.8.1 The questionnaire

A questionnaire is usually made up of numerous questions given to a respondent to complete. The questions are read and interpreted; the answers are then recorded or selected by the respondent (Collis & Hussey, 2014). There were two basic types of questions used in this research:

- **Closed-ended questions –** Answers are already listed and respondents are required to select the answer; e.g. multiple choice questions. The responses can be used to generate statistics.
- **Open-ended questions –** Respondents answer in their own words. The respondents enter the answers into blank sections left for this purpose.

This research survey used a structured questionnaire with the aim of collecting descriptive data. The qualitative interview used open-ended questions.

3.8.2 Biographical data

Biographical data is collected for two main reasons.

1. To ensure that the data collected represents the population.
2. To identify if any correlation exists between biographical data and lean awareness

This is achieved in this study by ensuring the following:

- Staff at all employment levels are represented in the data.
- Staff of differing ages are represented in the sample.
- Staff working in different departments are represented.
- Staff with different years of experience are represented.
- The data represents the entire population.

The biographical data collected in the survey is summarised in Table 3.6.

Table 3.6: Biographical data collected in the survey

1	Gender
2	Age
3	Years of experience
4	Department
5	Role

3.8.3 Lean implementation questions

The questionnaire was developed based on information gathered during the literature review. Pettersen (2009) grouped the lean tools into bundles which are summarised in Table 2.11. These bundles were cross-referenced against the lean tools appearing in key references summarised in Table 2.12. The questionnaire is included as Appendix 4.

The most commonly used tools, identified in the literature reviewed, were selected to develop the questionnaire. The questions were simplified so that they could easily be understood by the respondents and the practices could be identified even by people without a detailed understanding of lean.

Appendix 5 summarises the design structure of the questionnaire, linking the category with the questions and some of the tools related to these questions.

A question on the definition of lean was also included to determine employees' understanding of lean at GUD. This was done to give a good indication of how lean is implemented at GUD. In addition, a question on the amount of training received on lean was included.

3.8.4 The structured interview

The lean methodology was developed for GUD by a cross-functional team and the implementation focused on a few tools. The members of the original cross-functional team were interviewed to gain more insight into the thinking applied to the development of the lean programme. The structured interview questionnaire is included as Appendix 6.

The data collected from the interviews were also compared to the data collected from the surveys to check for validity of the findings, where possible. The structured interview uses more open-ended questions and allows the participant to discuss the answers, where appropriate.

3.8.5 Addressing the research objectives

An important issue to consider in designing the research questionnaire is to make sure that all the research objectives will be addressed by the questionnaire. Appendix 7 serves to show how the research objectives identified in Chapter 1 are linked to the questionnaire and structured interview questions.

3.8.6 Other considerations in questionnaire design

There were several considerations when designing the questionnaire which are discussed under the ethical approach to the research. Some practical considerations are noted here. The researcher took the following into consideration when designing the questionnaire:

1. To keep the questionnaire as short as possible, without compromising the data collection, because the questionnaire was administered during working hours.

2. To ensure that the questions were short and easy to understand as English may not be the participants' first language.

3. To keep terminology simple and avoid jargon as lean terminology may be different from terms the participants are familiar with.

4. Not to use leading questions.

5. To use a scale and questionnaire format that the participants would be familiar with.

6. To keep the scale the same for as many questions as possible to avoid creating confusion with multiple scales.

3.8.7 Pretesting and validity

Validity was discussed previously and is basically ensuring that the instrument does what it is supposed to do. One way of ensuring validity is to test the research instruments in order to find and fix any problems that may be identified.

After the design of the questionnaire had been completed, the questionnaire and the objectives were sent to two former colleagues who had previously completed their masters and had conducted research. This was done to ensure that the questionnaire was clear, unambiguous and the research question would be addressed. Suggested changes were taken into account and the questionnaire was updated.

The first group to complete the questionnaire was made up of five Industrial Engineering interns who had been employed at GUD for more than 18 months. This group completed the questionnaire in a meeting room where the researcher was present and able to address any queries. This group provided feedback on the questionnaire and identified areas they could not understand and suggested improvements. The following are some of the problems that were identified and addressed:

1. The numbering was incorrect as the number seven appeared on two pages.
2. The font was too small and they had difficulty reading the longer questions.
3. There were some spelling corrections.

4. There was an error with the age scale 0 to 49 instead of 40 to 49.
5. The questionnaire was long and took about ten minutes to complete.
6. The interns would have preferred to write their own definition of lean in Question 7 rather than select from a list. This question was not changed as the definition was related to the study objective one and objective two.
7. Question 7 (definition of lean) should not mention 5S, but INONO which is the term employees of GUD are familiar with.
8. Question 7 should specify that it seeks the definition of lean at GUD.
9. Question 6 should also specify that it relates to lean training received at GUD.

Once this process had been completed, the questionnaire was finalised. A copy of the questionnaire was also sent to the University Ethics Committee in order to obtain ethical clearance. After ethical clearance (Appendix 10) had been received, the questionnaire was administered.

3.9 Data analysis

3.9.1 Quantitative data analysis

Quantitative data analysis involves three major steps, as described below (Sekaran & Bougie, 2016).

Getting the data ready for analysis:

- Coding and data entry – Assign a number to responses from each participant and enter into a database.
- Editing data – Deciding how to handle blank responses, checking inconsistent data and detecting and correcting illogical data.
- Data transformation – This step may involve combining scores when several questions have been used to measure a single concept. Scores are combined to derive a single score for the concept.

Getting a feel for the data:

- Frequencies – The number of times an event occurs.
- Measures of central tendency and dispersion – Central tendency involves finding the average, the central value and the most frequently occurring value.
- Relationships between variables – Involves determining the nature, direction and significance of relationships between variables.

Descriptive statistics:

- Maximum, minimum, mean, standard deviation and variance – Can be done using statistical computer software.
- Reliability and validity tests – Check for reliability and validity using statistical methods.
- Correlation matrix – Indicates the direction, strength and significance of relationships between variables.

Completed survey questionnaires were entered into an Excel spreadsheet. The computer program was used to analyse the data to create the following statistics:

- Descriptive statistics in terms of frequencies, or percentages, of the respondents;
- Measuring the instrument's reliability; and
- Comparative dispersion statistics to describe the data relative to the qualitative variables, comprising mainly the functional areas of employment, geographic location, age generation, and job position in the organisation.

3.9.2 Qualitative data analysis

Qualitative data analysis also involves three major steps, as described below (Sekaran & Bougie, 2016).

- Data reduction – Selecting, coding and categorising the data.
- Data display – Presenting the data in ways that illustrate patterns in the data.
- Drawing conclusion – Answering the research questions.

3.10 Limitations of research

The research activities followed the stages of data collection and analysis. The methods of data collection and data analysis, however, were subject to issues that need to be highlighted.

3.10.1 Data collection issues

The majority of the respondents in the research did not speak English as a first language. The consent letter (Appendix 1 and Appendix 2) was therefore translated into Zulu so that respondents could understand the need for the research. The questionnaire was also administered with the inclusion of people who could understand both Zulu and English to provide guidance where required.

The letter of introduction (Appendix 3) and consent letter were discussed with everyone before the data collection began. Respondents were sceptical about participating in the study as they were not sure what outcomes were expected. Reassurance was given to participants that their contribution would remain anonymous, and that the aim of the study was to improve the way we do business, not to victimise people.

It took many attempts to collect the data on the production lines as the priority was to run production. The original intention was to collect information during the morning meetings, but it became clear that this was not enough time. Instead, smaller groups were allowed to participate during changeover and when there was a stoppage on the line, for example during a power outage.

After the first questionnaires had been collected, it was noted that there were blanks for some questions. This could not be corrected as the respondents were anonymous. Where numerous blanks were noted, the questionnaire was discarded. The coding was adjusted to count blanks and all graphs of responses also show blanks. For all future data collection, people were encouraged to choose an answer even if the answer is neutral, rather than leave blanks.

It was also difficult to get the people involved in the structured interview to commit to timing to participate. Eventually, meeting requests were used for participants based in Durban and a participant based in Pietermaritzburg agreed to complete the interview via email and discuss the responses telephonically.

3.10.2 Data analysis issues

Table 3.7 summarises the coding used to enter the data collected into an Excel spreadsheet. The responses could be counted using formulae and converted to percentages. The same approach was used to code and summarise the biographical data.

Table 3.7 Coding of responses

Strongly Agree	**1**
Agree	**2**
Neutral	**3**
Disagree	**4**
Strongly Disagree	**5**
Blank	**6**

The data was entered manually into the Excel spreadsheet and this meant there could be human error in the data entry. The data was therefore checked to ensure there were no input errors.

Where required, the data was correlated against biographical information from GUD or information gathered from the structured interview to ensure there were no anomalies or errors.

3.11 Ethical approach to research

Research ethics relates to "the appropriateness of the researcher's behaviour in relation to the rights of those who become the subject of a research project, or who are affected by it" (Saunders *et al*., 2009).

The general ethical issues are described by Saunders *et al*. (2009) as follows:

- Privacy – Participants have a right to privacy.
- Voluntary nature – Participants have a right not to participate.
- Consent – Participants have a right to informed consent.
- Deception – Participants should not be deceived.
- Confidentiality – Participants have a right to confidentiality.

- Anonymity – Participants have a right to anonymity during data collection and reporting.
- Stress – Participants should not be subjected to questions that may cause stress.
- Harm – Participants should not be subjected to questions that may cause harm.
- Discomfort – Questions must not cause discomfort to participants.
- Objectivity – Research needs to maintain objectivity at all times.

The nature of participant consent is summarised in Figure 3.4. The range extends from "lack of consent" to "informed consent". The arrow depicts the degree of ethics employed in research.

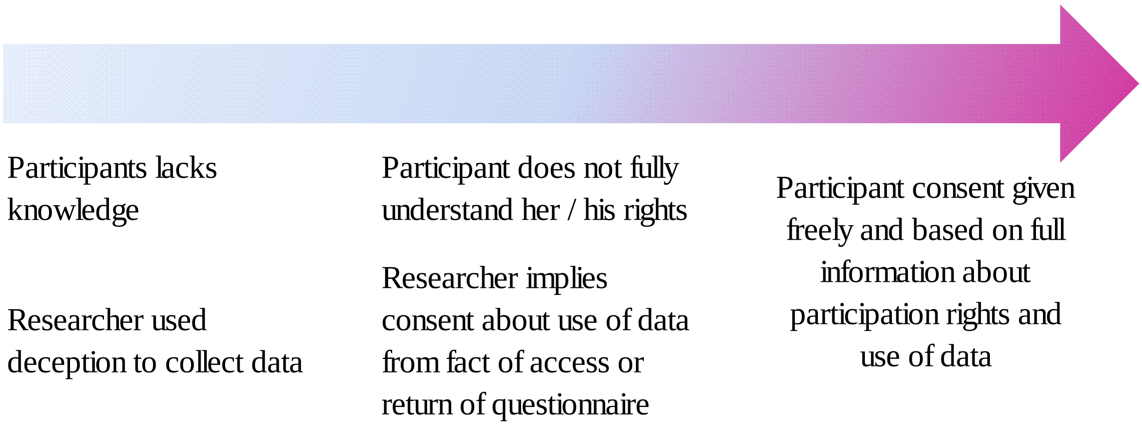


Figure 3.4 The nature of participant consent

Adapted from Saunders, M., Lewis, P., Thornhill, A., 2009. Research Methods for Business Students. 5th Ed. Harlow: Pearson Education.

Informed consent was obtained from all employees who participated in the data collection process. The rights of participants, use of data collected, and the right not to participate was communicated verbally and in writing. The consent form and the cover page of the questionnaire were also translated into Zulu to ensure everyone was able to understand.

Confidentiality was considered at all stages of the research and all participants remained anonymous. The data collected and used in the study is not traceable back to individuals. Privacy and respect for participants was guaranteed by interviewing people in their own offices where possible and providing a safe environment to conduct the surveys.

As part of the ethical clearance obtained, it was noted that all data collected will be stored at the GSB&L and disposed of as per guidelines provided by the Ethical Clearance Committee.

Saunders *et al*. (2009) also summarised the various ethical issues at different stages in the research. This is presented in Table 3.8.

Table 3.8 Ethical issues at different research stages

Stage	Impacted	Rights
Formulating the reach topic	Researcher	Not forced by sponsor
	Sponsor	Helpful research
Research design and access	Researcher	Not forced by gatekeeper
	Participant	All should be fully informed
		Privacy must be ensured
	Sponsor	Helpful research
Data Collection	Researcher	Not forced by gatekeeper or sponsor
		Safety of researcher
	Participant	Informed consent
		Right not to participate
		No deception in collecting data
		Privacy must be ensured
	Organisation	Privacy must be ensured
	Sponsor	Helpful research
Data processing and storage	Participant	Processing and storing of participants data
Data analysis and reporting	Researcher	Not forced by gatekeeper or sponsor
	Participant	Privacy must be ensured
	Sponsor	Helpful research,

Adapted from Saunders, M., Lewis, P., Thornhill, A., 2009. Research Methods for Business Students. 5th Ed. Harlow: Pearson Education.

During the research process, the above table was used as a guideline to ensure that an ethical approach to the research was followed at every step.

3.12 Reliability of the questionnaire

Reliability is a test of the extent to which similar results would be achieved if the study is repeated under the same conditions (Saunders *et al*., 2009). This would require the questionnaire to be administered twice, which is not practical. The reason for this is that participants were randomly selected and it would be difficult to select the same respondents again or to convince them answer the questionnaire twice.

A scientific way to test for reliability is to use split half reliability. This methodology essentially splits the questionnaire into two halves and compares each half for every respondent. If the scale is reliable, the two halves should closely resemble each other. If several participants are considered, high correlations would be a sign of reliability (Collis & Hussey, 2014). The problem with this method is that the result is dependent on how the data is split and there are usually many ways to split the data. Cronbach's alpha tries to split the data into two halves in every possible way and calculates the average correlation coefficient for every split (Sekaran & Bougie, 2016).

A reliability analysis was carried out using 37 questions and 132 respondents. The results are summarised in Table 3.9. Cronbach's alpha showed the questionnaire to have a computed reliability of α = 0.823. According to Sekaran and Bougie (2016), an alpha over 0.8 can be considered to be good. The questionnaire therefore has good reliability.

Table 3.9 Cronbach's alpha results

Cronbach's Alpha	0.823
Split-Half (odd-even) Correlation	0.792

Questions	37
Subjects	132

3.13 Chapter summary

This chapter summarised the research methodology employed in conducting the research. The research commenced with the formulation of the research topic and a review of the current literature on the topic. The participants and location of the study were also discussed. Choosing the research philosophy was followed by formulating the research design.

Data collection aspects, including sample size, data quality and the research instrument were discussed. This was followed by a discussion on data analysis. Limitations of the research and the ethical approach were also presented in this chapter. The chapter concluded with a discussion of Cronbach's alpha and the reliability of the questionnaire.

On completion of the data collection from the survey and the structured interviews, the next chapter comprises a presentation of results. The results of both the structured questionnaire and the structured interviews are discussed.

CHAPTER 4

Presentation of results

4.1 Introduction

The previous chapter focused on describing the research methodology and the considerations for design of the research. The results of both the structured questionnaire and the structured interviews are discussed in this chapter.

Once all the data had been collected and coding completed, the data set was used to analyse the responses. The data are presented as graphs and tables in order to keep it simple and present only information that helps to understand the observation being discussed. Graphs are predominantly used to make comparisons and show relationships. Complex statistical analysis was not required for this project.

The structured questionnaire results are summarised under two main sections. Firstly, the biographical data, and secondly, the data related directly to lean implementation at GUD. The structured interview data is summarised thereafter.

4.2 Biographical analysis

The main biographical information collected in the survey was listed in Table 3.6. Respondents were asked to indicate their gender, age, years of experience, department and role in the company. Respondents were talked through the biographical area of the questionnaire to improve accuracy.

4.2.1 Response by gender and age (Question 1 and Question 2)

The main purpose of collecting this information was to ensure that the data collected represents the population of GUD employees.

Based on the graphical representation of responses to Question 1 on gender (Figure 4.1), it is evident that there are more male respondents (60%) than female (40%). This is in keeping with the ratio of male and female employees at GUD.

The graphical summary of Question 2, the age of respondents (Figure 4.2), indicates a high number (70%) of employees are between the ages of 20 to 39. As the age increases, the number of employees decreases. This is also in keeping with the population of GUD employees.

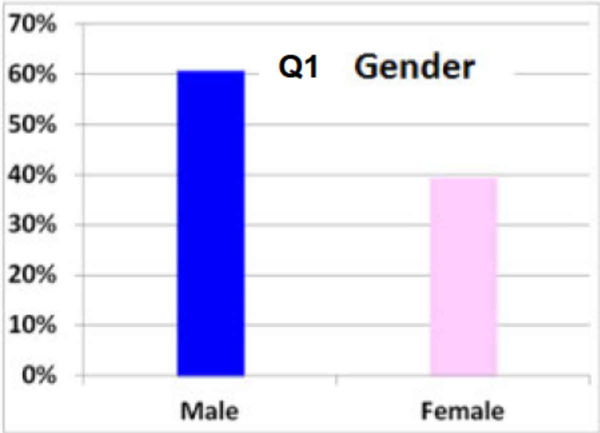


Figure 4.1: Gender of respondents

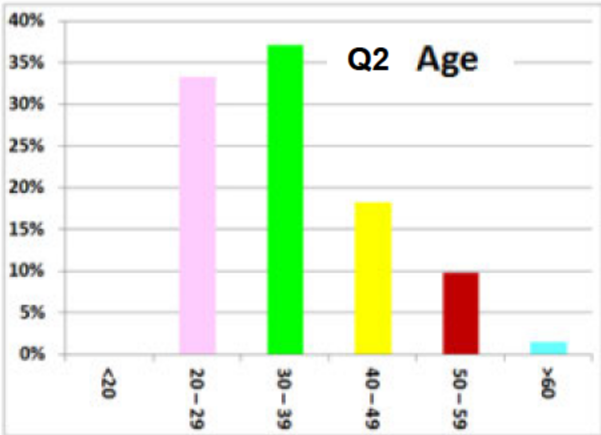


Figure 4.2: Age of respondents

4.2.2 Response by years of experience at GUD (Question 3)

According to Figure 4.3, more than 35% of respondents, were employed at GUD for a period of between one and three years, with a further 15% employed for less than a year. The balance of employees had been at GUD for more than four years.

Production lines were relocated from Pietermaritzburg and Cape Town in 2014, which would explain why there are so many employees with between one and three years of service. Contract labour is also used in some areas and this would explain the 15% of respondents with less than a year of service.

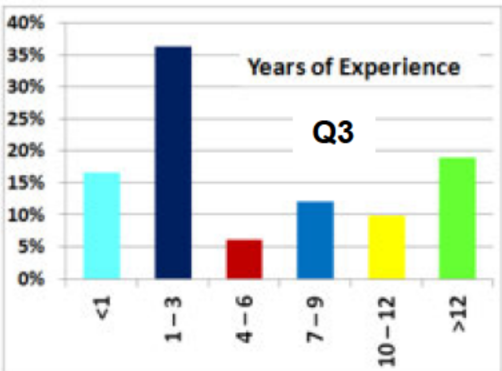


Figure 4.3: Years of experience at GUD

4.2.3 Response by department (Question 4)

The majority of respondents were from the Production department (66%). GUD has six manufacturing facilities on site and these account for the large number of respondents in Production. The data is summarised in Figure 4.4.

The next biggest areas were Production Engineering and Quality Engineering with 12% and Stores and Warehousing with 11%. These departments also fall under the control of the factory and are support functions for Production.

Technical (6%) and Engineering Services (5%) make up the balance of the departments.

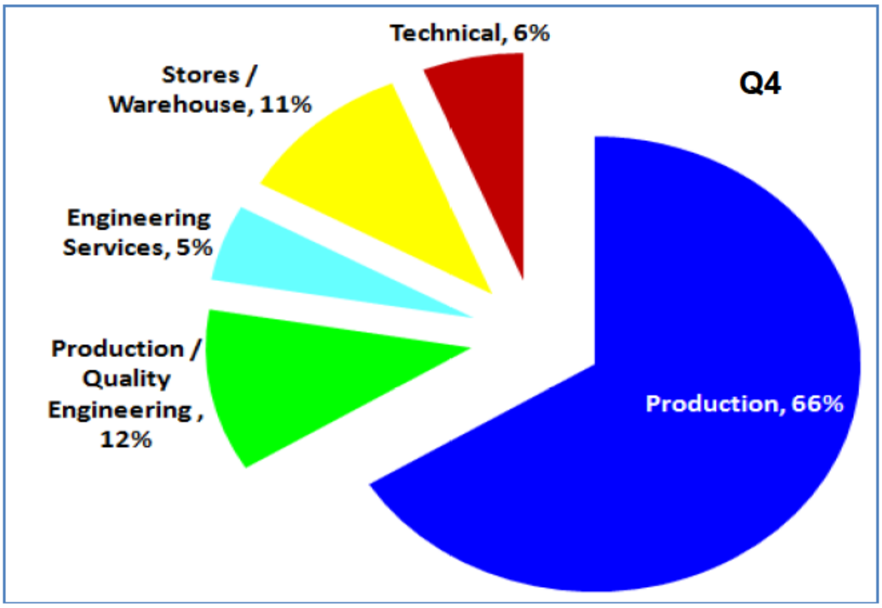


Figure 4.4: Response by department

4.2.4 Response by role (Question 5)

Figure 4.5 summarises the responses by role of the respondents. Operators lead the way with close to 50% of responses. The distribution of roles within GUD is fairly represented in the graphic of responses below. The majority of people are employed at Operator level, followed by Supervisors and Superintendents.

The category of "Production Support" combines departments, hence the large numbers.

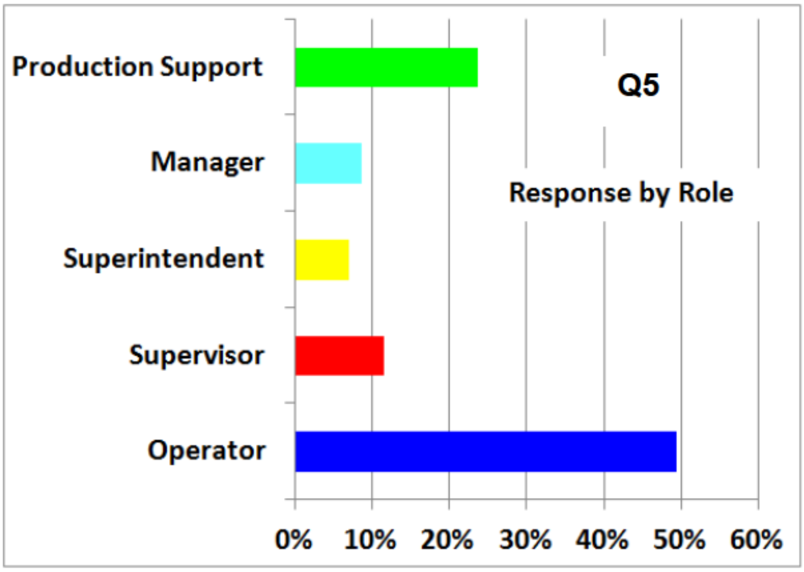


Figure 4.5: Response by role

4.3 Lean implementation questions

The lean implementation questions were aimed at obtaining an understanding of what tools were currently being applied at GUD and how these tools were applied to improve productivity. There was also a question on training and a question on the definition of lean included in this section.

The respondents were shown how to use the Likert scale to answer the questions and the respondents then handed in the questionnaire when they had completed it. In some questionnaires, there were questions left blank, and some questions had multiple selections. Due to anonymity of the respondents, these questionnaires could not be traced back to a person for correction, so these were coded under the label blank and in some cases the questionnaire was omitted from the study.

4.3.1 Hours of lean training received (Question 6)

According to Figure 4.6, 43% of employees have received less than one hour of training on lean since inception. A total of 30% of employees indicated between one and five hours of training on lean.

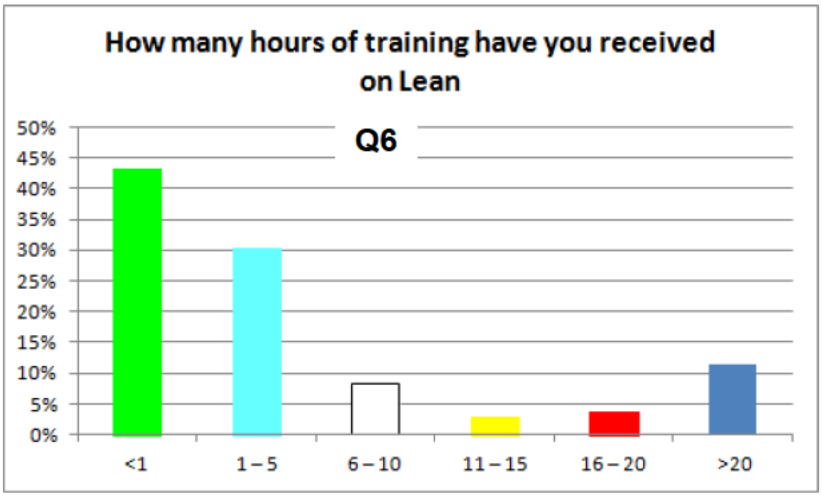


Figure 4.6: Hours of lean training received

To confirm if this finding is common across departments or isolated to some departments, the result per department is summarised in Figure 4.7. According to Figure 4.7, all departments surveyed show the same outcome. All departments peak at less than one hour of training.

An exception is noted for Production and Quality Engineering where there is a peak at "more than 20 hours". Most employees in these departments have a formal qualification (Mechanical or Industrial engineering), and are involved in problem-solving and productivity improvement projects.

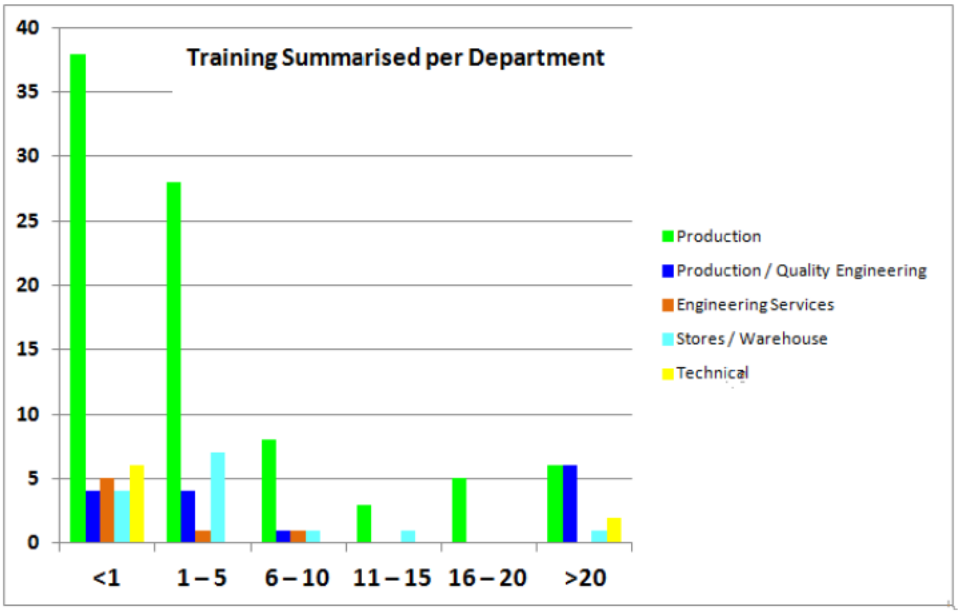


Figure 4.7: Hours of lean training received across departments

The hours of training received are also summarised per role in Figure 4.8. This was to determine if training increased as the level of responsibility increased. It was again evident that the majority of respondents had received less than five hours of training, regardless of the level in the organisation. Production and Quality Engineering form part of Production Support.

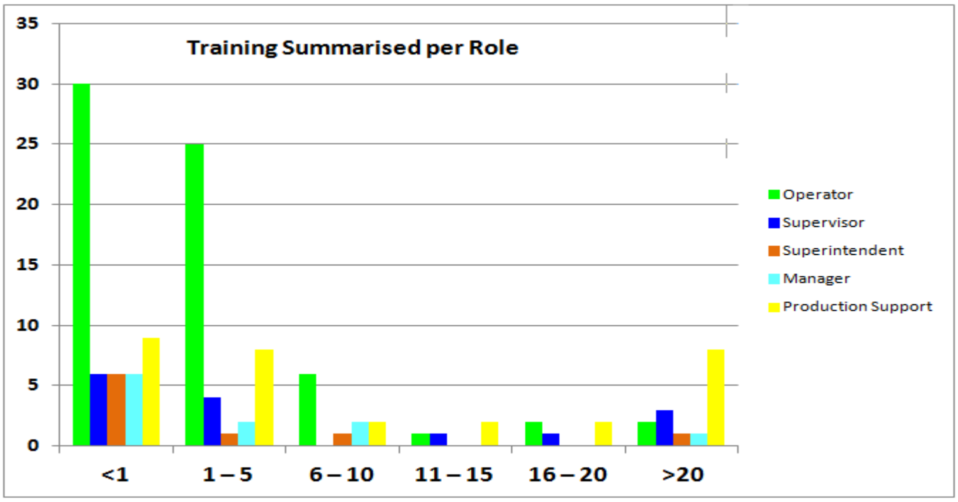


Figure 4.8: Hours of lean training summarised per role

4.3.2 The definition of lean (Question 7)

This question was specifically phrased to determine the definition of lean at GUD. There were 2% blank responses. The majority of respondents (47%) saw the definition of lean as "Visual Management and Inono" (Figure 4.9). Inono is the localised version of 5S used at GUD.

The second highest response rate (19%) was for "Empowering people to continuously improve" and the third highest (18%) was for "Elimination of waste from all operations".

The literature review identified "Empowering people to continuously improve" and "Elimination of waste from all operations" as definitions of lean used to drive productivity improvement in previous research. The results of this survey suggest an understanding of what is already present at GUD, but not a greater understanding of where "Visual Management and Inono" fit into lean.

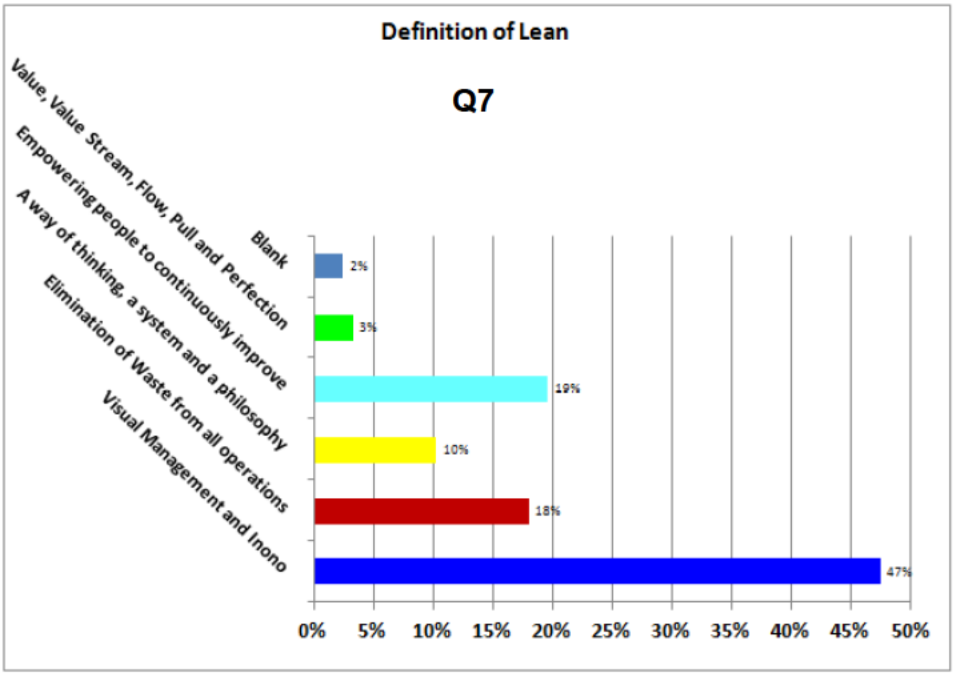


Figure 4.9: Definition of lean

To investigate if this finding is common across departments or isolated to some departments, the result per department is summarised in Figure 4.10.

It is evident from Figure 4.10 that the findings are common across all departments. The responses peak at number 1, "Visual Management and Inono".

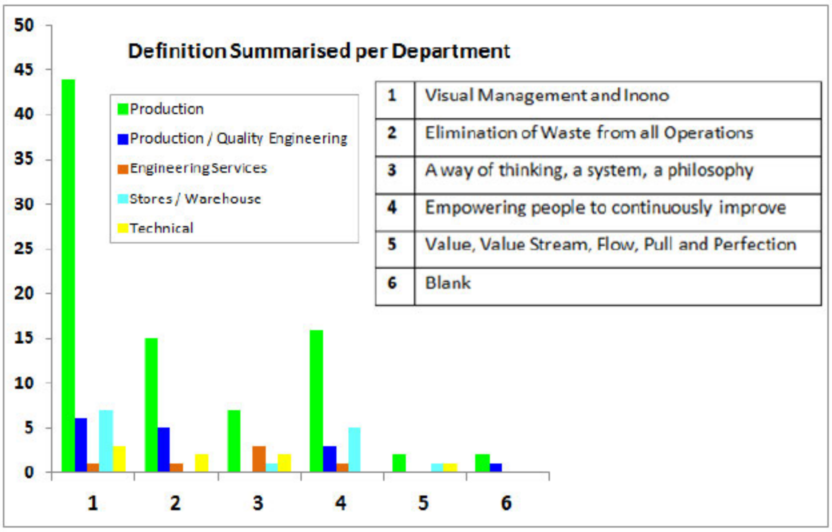


Figure 4.10: Definition of lean summarised per department

The same result is largely evident when comparing the results per role in Figure 4.11. However, there is one exception in that the results for Supervisors peak at definition number 4, "Empowering people to continuously improve".

Of the total supervisor responses, 57% defined lean as "Empowering people to continuously improve".

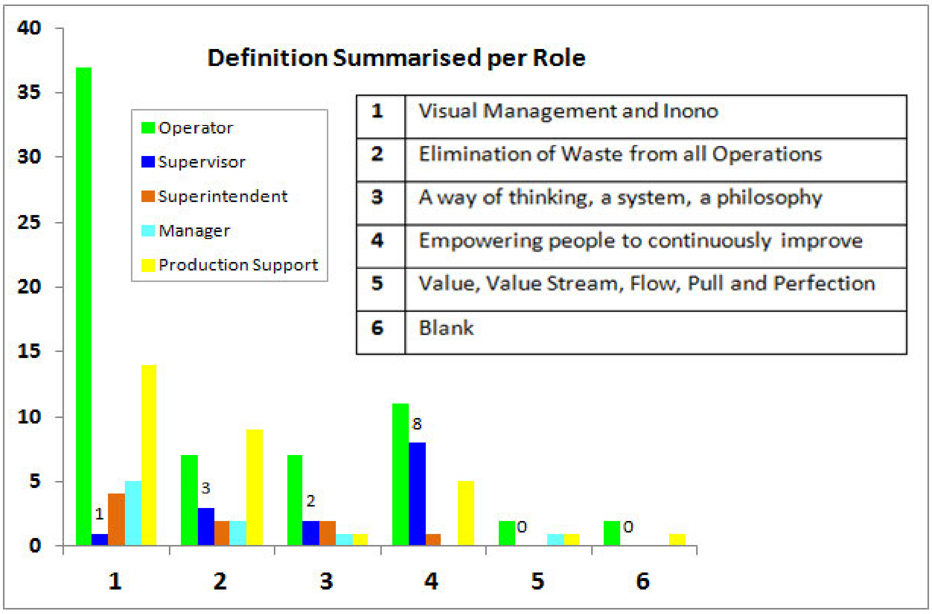


Figure 4.11: Definition of lean summarised per role

4.3.3 Just-in-time practices

Table 4.1: JIT practices questions

Category/Bundle	Question Number	
Just-in-time Practices	8	I know what my daily production targets are.
	9	My daily production targets are always met.
	10	Peak periods are identified and resultant increased volume is taken into consideration when planning.
	11	My team improves the flow of work by eliminating delays.

The questions related to JIT are summarised in Table 4.1. A compilation of all the results for these questions are summarised in Figure 4.12, to get an overall picture of JIT implementation to drive productivity improvement at GUD. A majority of participants (50%) agreed or strongly agreed (17%), with 17% having neutral responses.

Considering that 66% of the respondents were from Production (Figure 4.4), a total of 67% 'agree' is a very strong indication of the presence of JIT practices. Some departments like Engineering Services may find it difficult to identify JIT in their area.

A further 14% indicated 'disagree' (12%) or 'strongly disagree' (2%). Further analysis of the data indicates a majority of the 'disagree' responses were from Production Support departments (Production and Quality Engineering, Technical, Store and Warehouses). Previously it was observed in Figure 4.7 that Support departments like Production and Quality Engineering peaked at more than 20 hours of lean training. These departments have a deeper understanding of lean and results here may indicate that the JIT practices observed are very basic implementations.

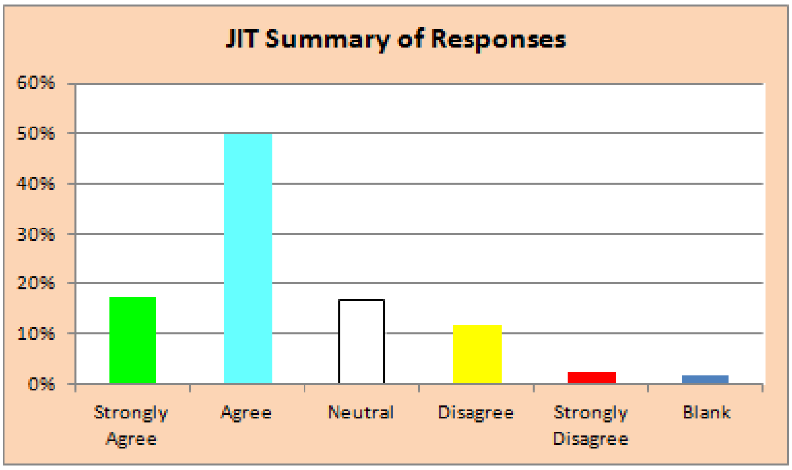


Figure 4.12: JIT summary of responses

The results for the individual questions on JIT practices are summarised in Figure 4.13. A peak is noted for 'disagree' with Question 9 (My daily production targets are always met). This is possibly an indication that there is inconsistency in achieving targets in some areas. The daily production targets are directly related to outputs which will impact on the productivity of the department.

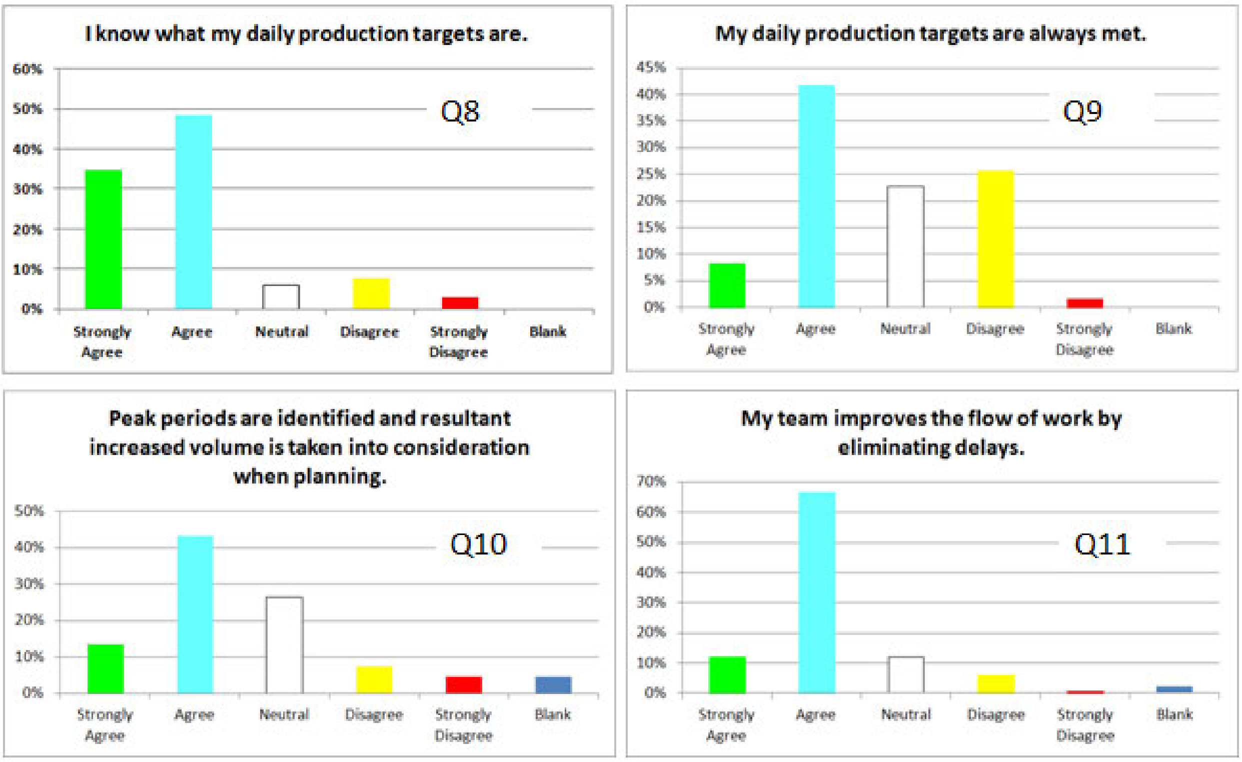


Figure 4.13: JIT summary of individual questions

4.3.4 Resource reduction

Table 4.2: Resource reduction questions

Category/Bundle	**Question Number**	
Resource Reduction	12	I understand the concept of 'value adding' activities.
	13	My department actively manages inventory to minimise the amount of stock in the internal component stores.

The questions related to Resource Reduction are summarised in Table 4.2. The overall summary of responses for this area is presented in Figure 4.14. Resource reductions are directly related to inputs into the process and therefore impact directly on productivity.

Strongly agree (20%) and agree (54%) account for 74% of the responses, whilst 16% were neutral. A total of 7% of respondents did not agree. This is a strong indication of a resource reduction being practised at GUD to improve productivity.

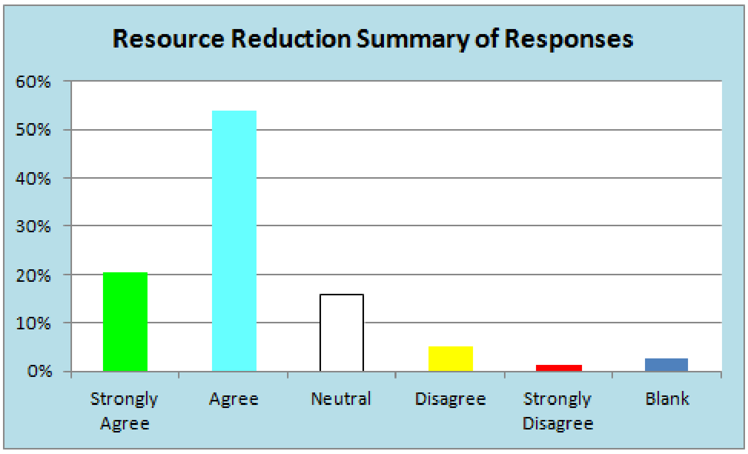


Figure 4.14: Resource reduction summary of responses

The results for the individual questions on Resource Reduction are summarised in Figure 4.15. A greater number of respondents 'disagree' with Question 13 (My department actively manages inventory to minimise the amount of stock in the internal component stores). The majority of these negative responses originate from the Support departments. This is possibly an indication that there are poor inventory management practices in some areas.

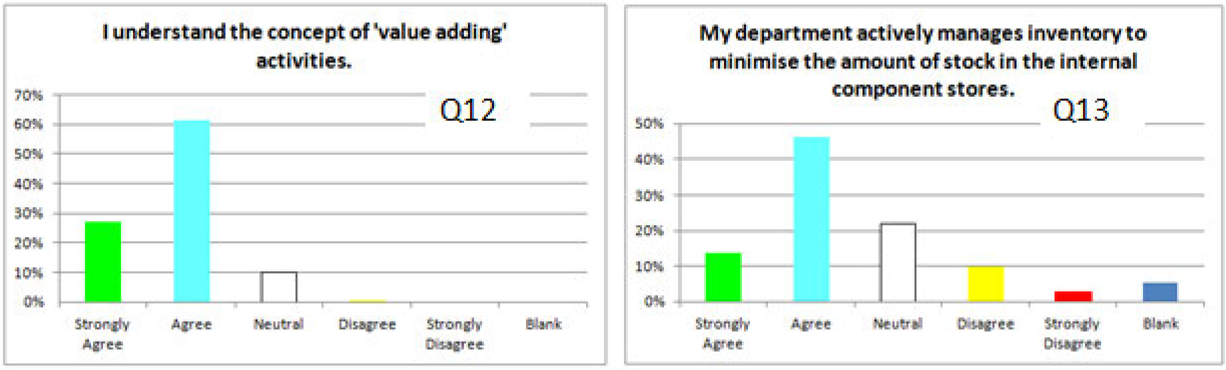


Figure 4.15: Resource reduction summary of individual questions

4.3.5 Human resources management

Table 4.3: Human resource management questions

Category/Bundle	Question Number	
Human Resource Management	14	I understand how my contribution helps GUD to achieve GUD's overall goals.
	15	I am able to perform a variety of tasks in my department.
	16	I am made aware of customer complaints that originate in my department.
	17	My team discusses how to improve customer satisfaction.
	18	My team makes suggestions for improvement.
	19	My team has had improvement suggestions implemented.

Table 4.3 lists the questions related to Human Resources Management and this category had the most questions. From the literature reviewed, employee involvement is one of the central themes of lean (Liker, 2004; Pettersen, 2009) and is crucial to achieving productivity improvement. The question on training (Question 6) also fits into this category, but has been discussed under a separate heading.

All responses in this category are summarised in Figure 4.16. A total of 78% of respondents agreed (51%) or strongly agreed (27%). A total of 7% of respondents disagreed in this category.

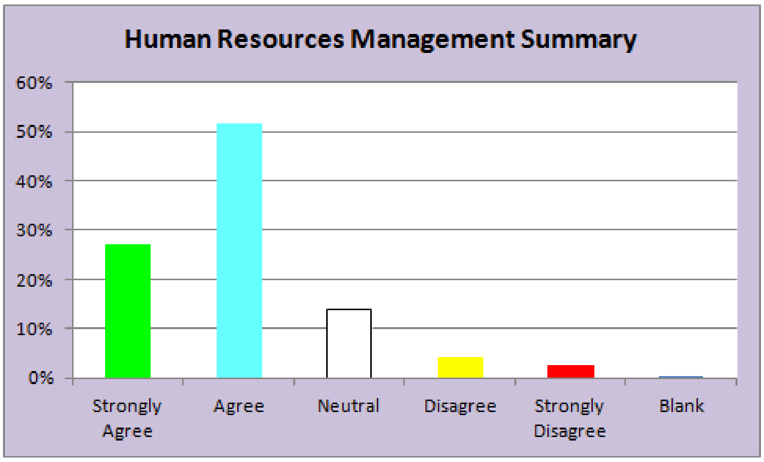


Figure 4.16: Human resources management summary

Analysing the questions for Human Resources Management summarised in Figure 4.17, it is evident that the responses are consistent across all questions. The 'agree' response is generally between 70% and 80%, with low levels of disagree for all questions, indicating a strong presence of these principles.

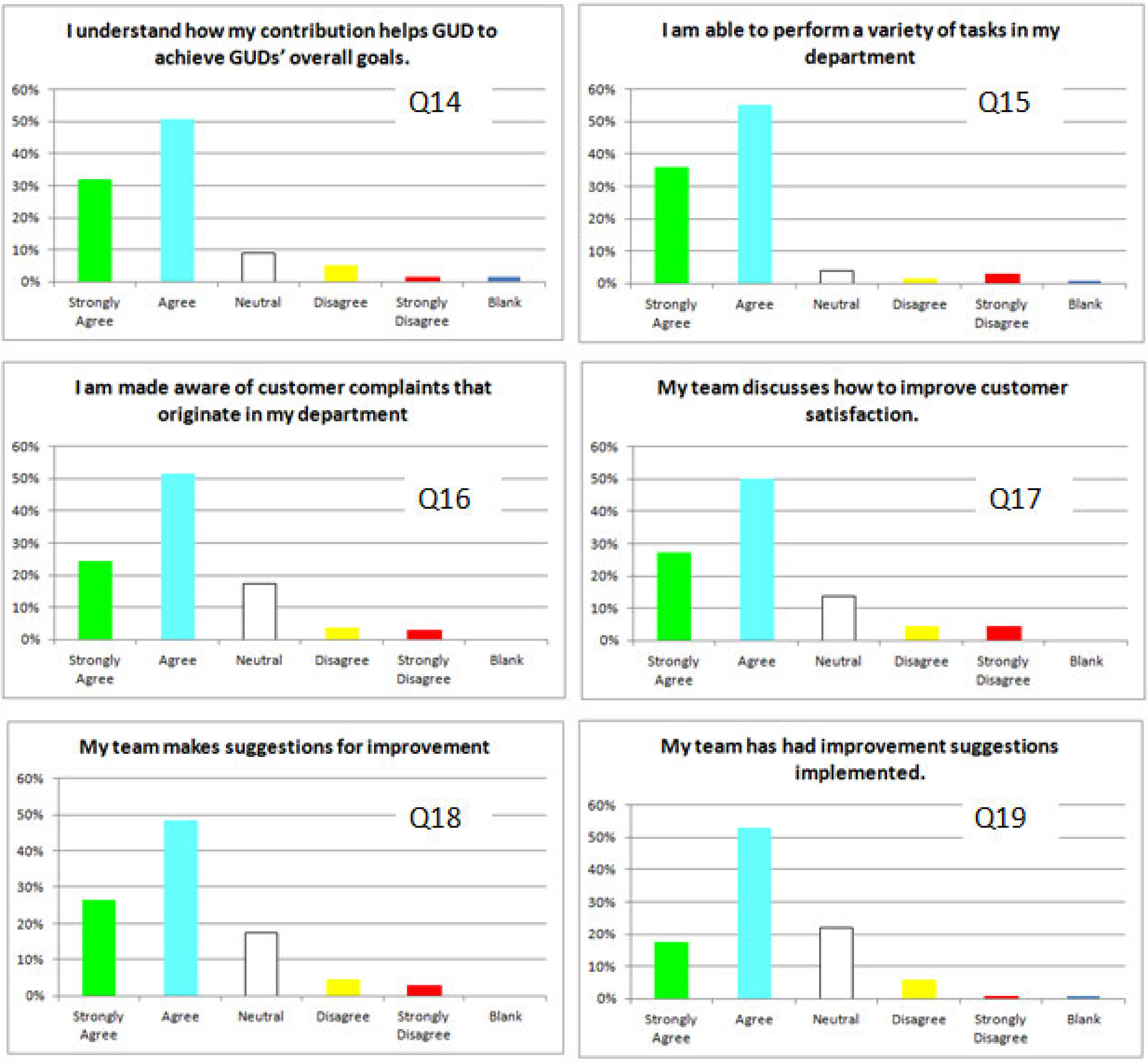


Figure 4.17: Human resources summary of individual questions

4.3.6 Improvement strategies

Table 4.4: Improvement strategies questions

Category/Bundle	Question Number	
Improvement Strategies	20	In the past two years we have solved many problems through teamwork.
	21	I join teams from different departments to help solve problems.
	22	When problems are experienced we find and address the root cause.

The questions related to Improvement Strategies are summarised in Table 4.4. All these questions are related to problem solving which is a direct driver of productivity improvement.

The overall result in this category is summarised in Figure 4.18. More than 55% of respondents agreed (39%) or strongly agreed (16%), whilst 22% were neutral. A further 20% either disagreed (13%) or strongly disagreed (7%). This category also had the highest number of blanks (3%).

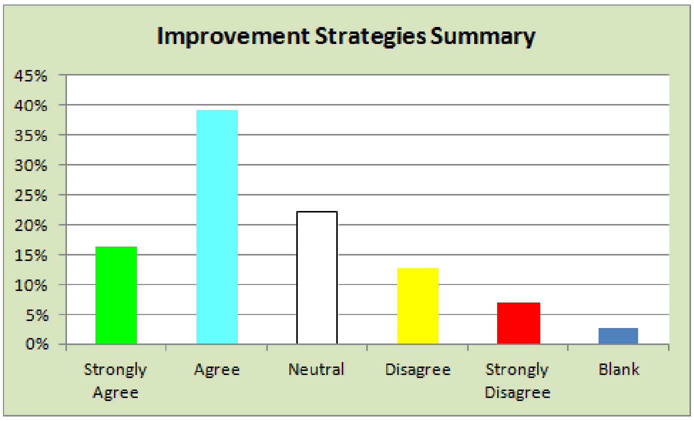


Figure 4.18: Improvement strategies summary

When analysing the response to individual questions, summarised in Figure 4.19, it is evident that respondents consistently disagreed or strongly disagreed across all questions. It therefore required a more detailed analysis per department and roles.

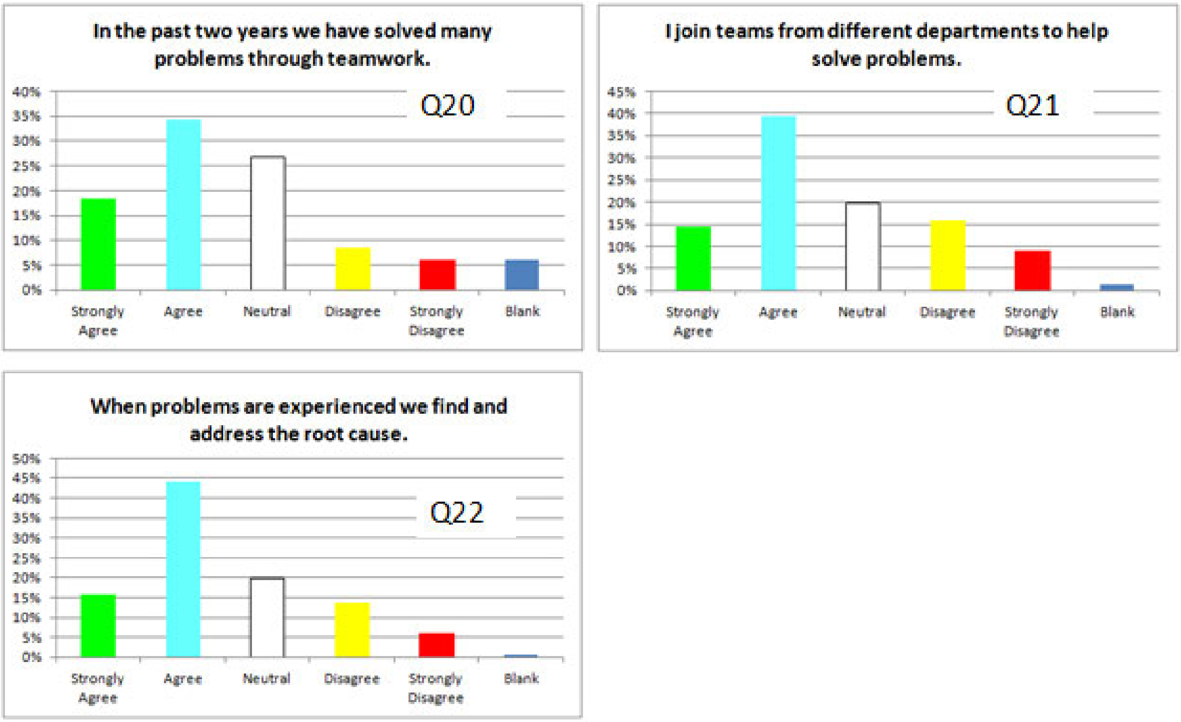


Figure 4.19: Improvement strategies summary of individual questions

Figure 4.20 summarises the responses across departments and roles. It is evident that the response is fairly consistent across departments and roles.
Even though the majority of responses indicate the presence of principles related to improvement strategy, there seem to be ‘pockets of excellence’ within GUD. Some areas have the principles in place, whilst some areas have not fully implemented the approach. This would explain the distribution of results across departments and across roles.

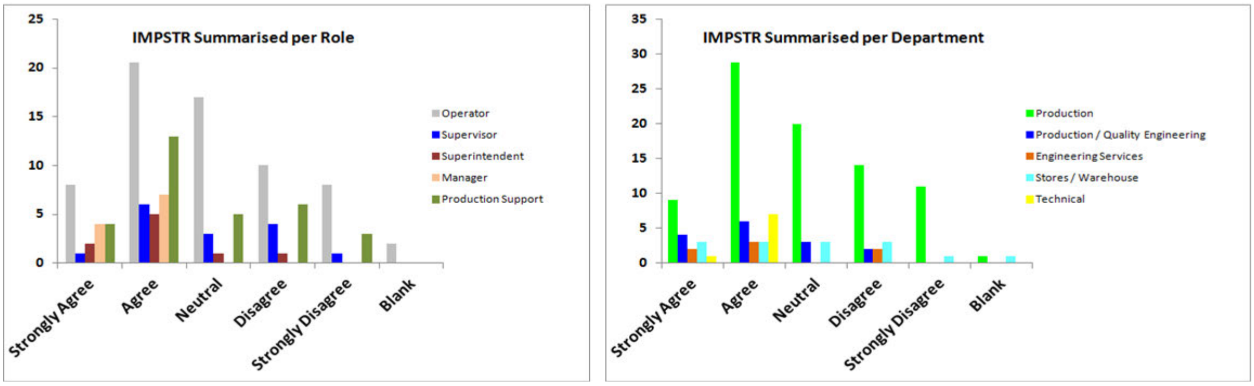


Figure 4.20: Improvement strategies summary per role and per department

4.3.7 Defects control

Table 4.5: Defects control questions

Category/Bundle	Question Number	
Defects Control	23	Our processes are designed to prevent errors.
	24	Errors are discovered at source and not later by downstream processes.
	25	Mistakes/Errors are often repeated, resulting in the same customer complaints.

The questions related to Defects Control are summarised in Table 4.5. This section can also be described as Quality Control and is linked to the previous section on Improvement Strategies. Quality is measured and improved using the improvement strategy. By addressing the root cause, the quality defects can be reduced or eliminated, thus improving output and driving productivity improvement.

The overall result in this category is summarised in Figure 4.21. More than 48% of respondents agreed (39%) or strongly agreed (9%), whilst 23% were neutral. A further 27% either disagreed (22%) or strongly disagreed (5%). This category also had 2% of blanks in the responses.

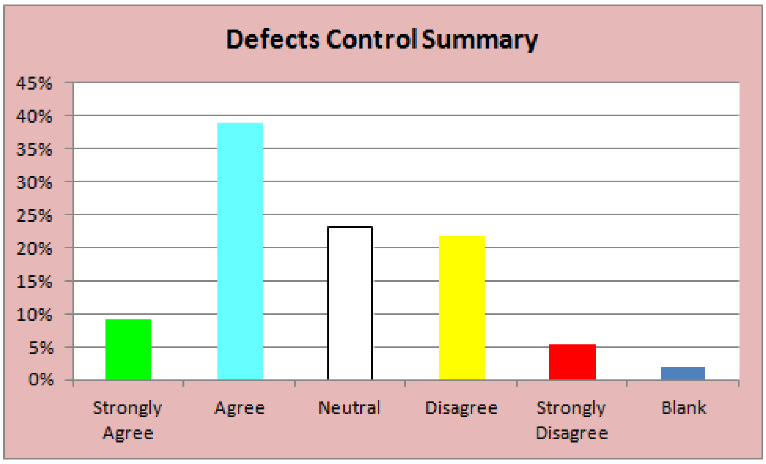


Figure 4.21: Defects control summary

When analysing the response to individual questions, summarised in Figure 4.22, it is evident that respondents consistently disagreed or strongly disagreed across all questions. The same pattern was evident with the previous category of Improvement Strategies. The category of Defects Control therefore required a more detailed analysis per department and roles.

Figure 4.22: Defects control summary of individual questions

Figure 4.23 summarises the responses for Defects Control across departments and roles. It is evident that the response is fairly consistent across departments and roles. Some small peaks are noted with the role of Production Support and for the Production/Quality Engineering department.

Even though 48% of respondents indicated the presence of principles related to defects control, 27% of respondents indicated a lack of this approach. As with the previous category (Improvement Strategies), the conclusion is that some areas have the principles in place, whilst some areas have not implemented these principles. This explains the distribution of results across departments and across roles.

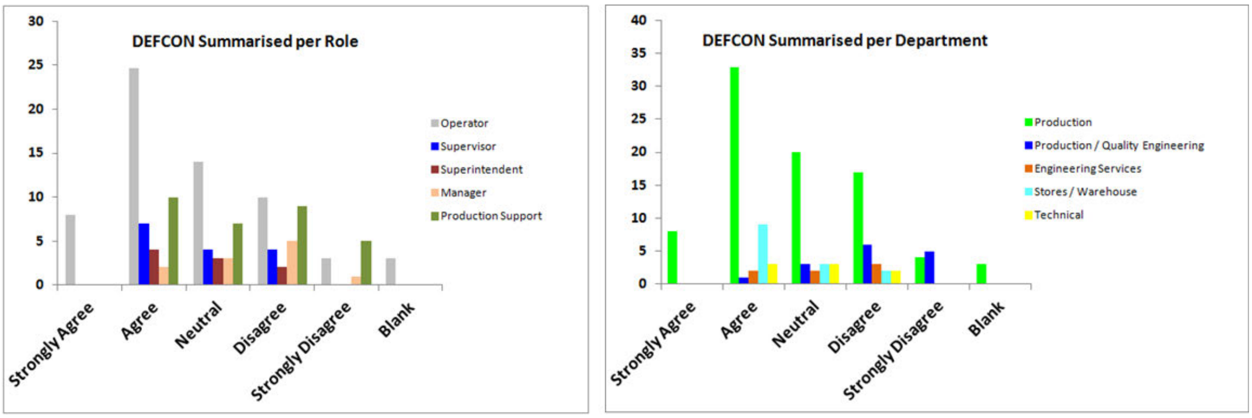


Figure 4.23: Defects control summary per role and per department

4.3.8 Supply chain management

Table 4.6: Supply chain management questions

Category/Bundle	Question Number	
Supply Chain Management	26	I understand what customers expect in terms of product quality.
	27	All customer complaints follow a specified flow.
	28	My department has made improvements by changing processes.
	29	My department communicates with customers regularly.
	30	My department communicates with customers to understand customer needs.

Table 4.6 summarises the questions in the Supply Chain Management category. According to the LEI (2017), lean means "creating more value for customers", and this category is aimed at determining if the company drives productivity by creating a focus on the customer.

In general, there is a high percentage of agreement with this statement. This is seen in Figure 4.24, the overall summary for the Supply Chain Management category. Strongly agree (25%) and agree (45%) account for 70% of the responses. This is a good indication that these practices are prevalent in the organisation.

Some respondents disagreed (6%) or strongly disagreed (3%) in this category, whilst 17% remain neutral. This can be an indication that there is still room for improvement in Supply Chain Management.

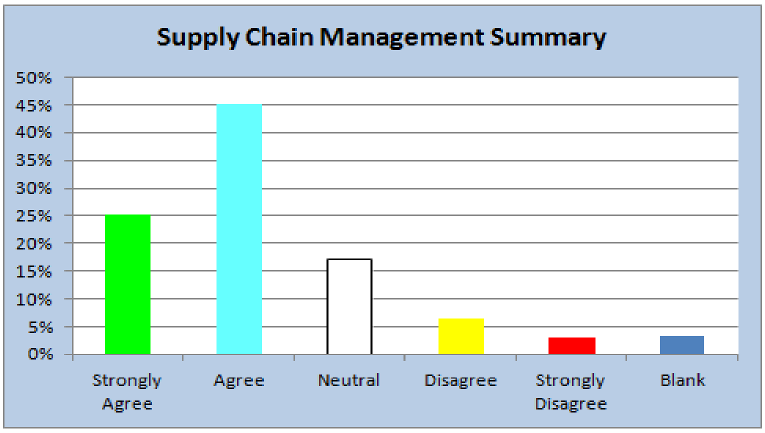


Figure 4.24: Supply chain management summary

The questions with the most positive responses are summarised below in Figure 4.25. Question 26 received 89% agree responses, whilst Question 28 received 70% agree responses. The data shows respondents understand what is required in terms of quality, and changes in processes suggest the presence of continuous improvement.

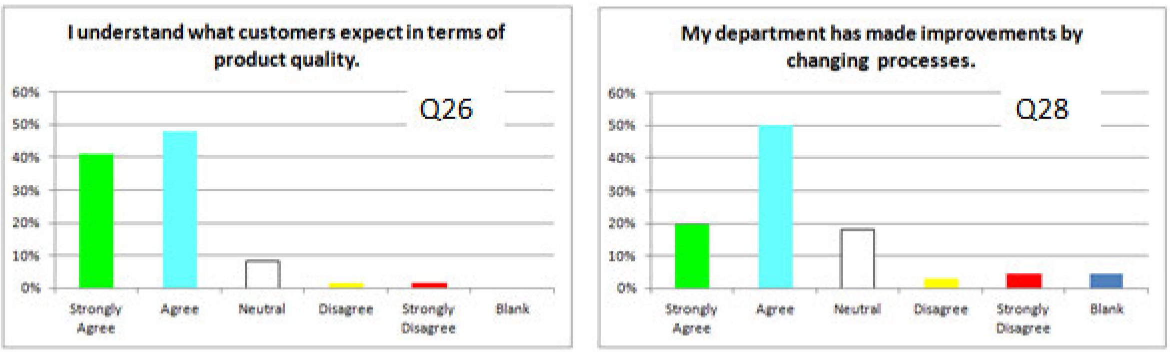


Figure 4.25: Supply chain management summary of Questions 26 and 28

The questions some respondents disagreed with are summarised in Figure 4.26. Even though these are not high levels of disagree (9%, 16% and 12%), these will identify areas where it is possible to improve further.

Question 29 had the highest levels of disagree with 16% and this question is related to communication with customers. This might be an indication of communication within the organisation, rather than communication with the customer. Most companies have specialised positions to deal with customers, but the people at lower levels in the organisation may not be aware of what communication takes place.

There were a total of 3% blank responses across all questions for this category.

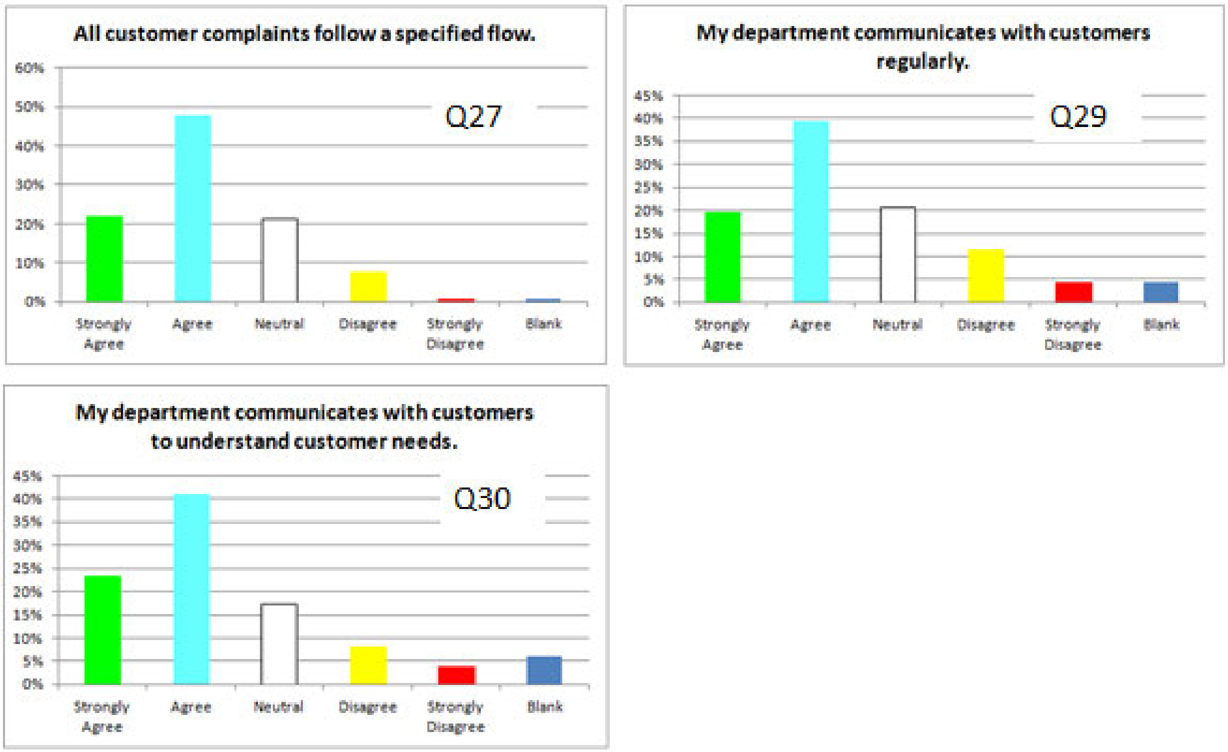


Figure 4.26: Supply chain management summary of Questions 27, 29 and 30

4.3.9 Standardisation

Table 4.7: Standardisation questions

Category/Bundle	Question Number	
Standardisation	31	My workplace is well organised.
	32	All the work I do is guided by standard operating procedures.
	33	I receive training on documented procedures.
	34	On a daily basis team performance is discussed.
	35	My department uses visual management to track performance.

The Standardisation bundle of questions is summarised in Table 4.7. Standardisation is used in order to limit variation in a process and achieve improved productivity (Smalley, 2017). There are numerous tools available to achieve this and the questions in Table 4.7 were designed to determine if these tools are present at GUD.

The results from the survey are summarised in Figure 4.27. Close to 70% of respondents indicated they agree with the questions, whilst there were low levels of disagree (13%) noted across most questions. A further 9% of respondents were neutral, whilst 5% of respondents left this question blank in returned spoilt questionnaires.

The data again indicates a strong presence of these tools, with room for further improvement in some areas. Some of the individual questions are looked at more closely and discussed further.

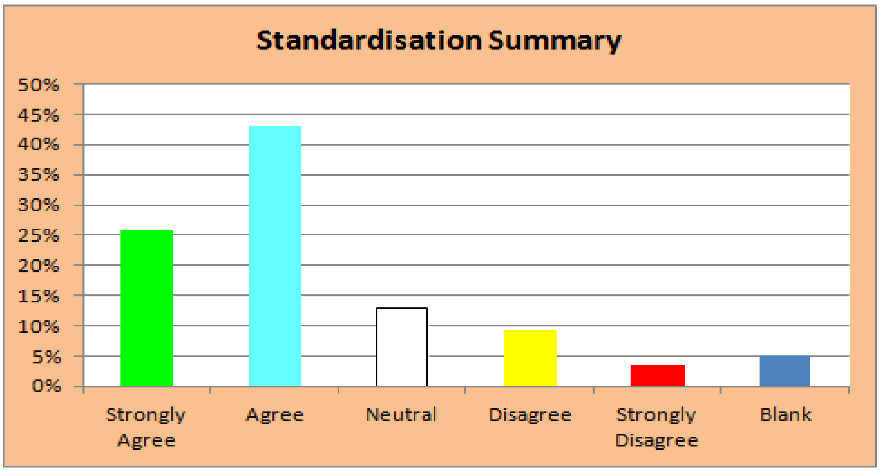


Figure 4.27: Standardisation summary

Figure 4.28 summarises the individual questions under the category of Standardisation. It is noted that Question 33 (17%) and Question 34 (23%) had higher levels of disagreement, whilst the highest agreement was with Question 32 (82%).

The result of 82% for Question 32 suggests a very structured environment with defined ways of doing things. This is in keeping with a company that is trying to reduce variation in processes.

The results for Question 33 and Question 34 suggest there is room for improvement in the areas of training on documented procedures and communicating performance. Team performance may also be discussed weekly or monthly and not daily in some areas.

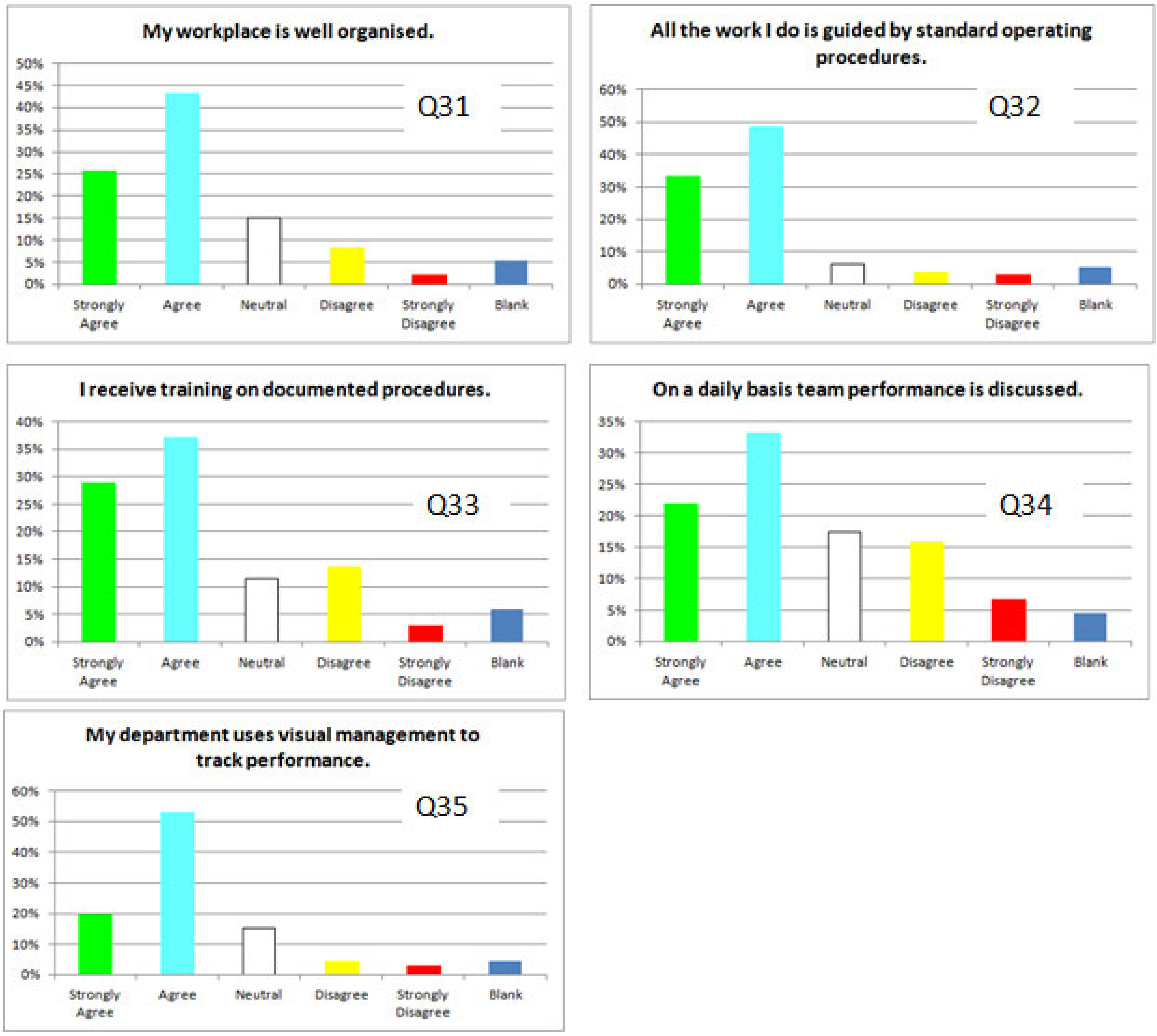


Figure 4.28: Standardisation summary of individual questions

4.3.10 Scientific management

Table 4.8: Scientific management questions

Category/Bundle	Question Number	
Scientific Management	36	All decisions made in my department are governed by company policies.
	37	My department changes layouts to improve material flow.

Scientific Management is an approach that emphasises the scientific study of work methods in order to improve productivity (Jones and George, 2009). The questions for the Scientific Management category are summarised in Table 4.8.

Analysing the overall results for Scientific Management summarised in Figure 4.29, it is evident that these principles are in place, with 64% of respondents agreeing. The neutral response was selected by 17% of respondents, whilst, 9% disagreed overall. A total of 5% of responses were left blank.

These results suggest there is room for improvement in some areas.

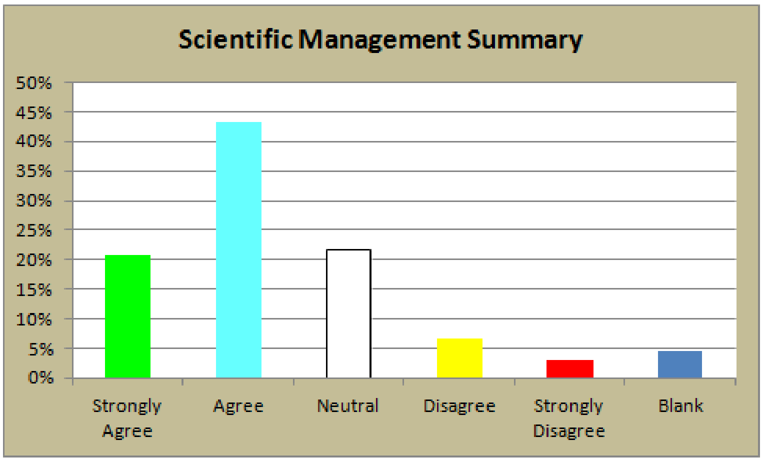


Figure 4.29: Scientific management summary

Looking at the individual questions in this category (Figure 4.30), shows Question 37 received higher levels of neutral (27%) and disagree (10%) responses. This is possibly due to the respondents from departments other than production being included in the survey. Engineering Services and Technical, for example, may not be involved in decisions on layout changes as this will mainly impact production departments.

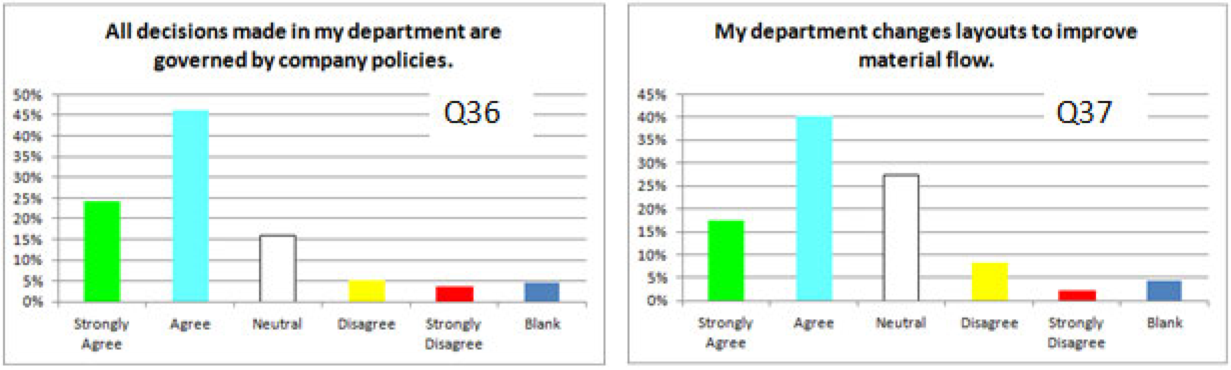


Figure 4.30: Scientific management summary of individual questions

4.4 Structured interviews

As discussed previously, in 2014 a cross-functional team put together a program called GUD Productivity System (GPS). Of the original team of 21 people, only eight people remain at GUD. All eight people were approached to participate in the research.

Three people indicated they were not really involved in the GPS development. Although all three were part of the cross-functional team, two people were restricted in their involvement due to their geographical location (Cape Town and Benoni), and the third person was involved in multiple projects and chose to have limited involvement in GPS.

The remaining five people were contacted, but only three people participated in the research. Two of the respondents are based at the Durban factory, whilst the third person is now based at the Pietermaritzburg factory. Their responses are discussed below.

4.4.1 Question 1

Table 4.9: Structured interview: Question 1

		Resp 1	Resp 2	Resp 3
1	**Why GPS? What was the reason for putting the program together?**	Need to Improve conversion cost.	Need identified for productivity improvements by senior management.	Need to improve problem solving

All respondents indicated a need to improve in some way as the driver for the GPS initiative. The general consensus was a need to reduce costs. This was highlighted by senior management putting together a cross-functional team to address productivity and process improvement. Some members of the team had experience in lean and moved the team in this direction.

4.4.2 Question 2

Table 4.10: Structured interview: Question 3

		Resp 1	Resp 2	Resp 3
2	**How did the team choose the tools / Design the program?**	The internet was used to find tools that were appropriateand would benefit GUD the most.	Most appropriate tools identified at the time for the business.	The team identified which tools were commonly used in production.

The selection of tools did not follow any scientific methods. The team used the internet and some members of the team had their own data on lean. The team identified tools they felt were appropriate for use at GUD and these tools became part of the GPS toolbox.

4.4.3 Question 3

Table 4.11: Structured interview: Question 3

		Resp 1	Resp 2	Resp 3
3	**What was the plan of action after the CFT?**	The team asked other departments to identify projects in their area.	No implementation plan.	Develop a training module for each of the tools and identify pilot projects

There was no formal plan for the implementation of GPS. The aim was to do more projects and get departments outside of Production doing projects as well.

The focus of the team was more around presenting the GPS programme at the management conference, rather than the long-term strategic benefits that could be realised by the implementation.

4.4.4 Question 4

Table 4.12: Structured interview: Question 4

		Resp 1	Resp 2	Resp 3
4	**How were people trained on GPS after the CFT?**	Some “on the job” experiential training was offered. Subject matter experts were trained.	Not many people trained.	Training was not done

Training after the conference was minimal. On the job training was done in some areas, and lean training was done with some staff. In some instances, no further training was carried out. One of the respondents indicated that subject matter experts were trained and have been deployed to do projects in different areas. This is in keeping with the findings from the quantitative data.

4.4.5 Question 5

Table 4.13: Structured interview: Question 5

		Resp 1	Resp 2	Resp 3
5	**What were the outcomes expected by doing GPS?**	Nothing was quantified. It was very informal and no milestones.	Increase output / productivity.	Effective and efficient problem solving, with sustainable corrective actions.

There were general expectations of improvements in productivity and problem solving, but these were very informal. One respondent indicated there were no milestones against which to measure progress.

4.4.6 Question 6

Table 4.14: Structured interview: Question 6

		Resp 1	Resp 2	Resp 3
6	**What is your view of where we are now? Have we achieved the GPS objectives?**	There is a culture of continuous improvement. There is room for improvement.	GPS only used in silos. Individual approach rather than team approach	Only members of the original team really put some of the tools into practice.

When discussing the progress and achievements of GPS, all respondents identified problems with the current approach. However, there was consensus that there has been improvement in productivity and creating a culture of productivity improvement. The two main problems identified were the lack of a team approach and limited use of the tools. One respondent indicated the tools were used by some of the original GPS team members only. This is similar to the findings from the quantitative data.

4.4.7 Question 7

Table 4.15: Structured interview: Question 7

		Resp 1	Resp 2	Resp 3
7	**Has new managers / staff been trained on GPS?**	No. This is not part of induction. It is not a prerequisite.	No.	No.

All respondents agreed that there has been no additional training on GPS. Even with 13 of the original team moving to other companies, the people who have replaced them have not been formally trained in the GPS. This could explain the inconsistency identified by the quantitative data.

4.5 Chapter summary

This chapter presented the results for both the structured questionnaire and the structured interviews. The data was analysed and quantitative data was presented as graphs and tables. The results were presented in sections following the structure of the questionnaire.

The demographic information was presented, followed by results from the lean implementation questions. The majority of the data was converted to percentages for ease of understanding and ensuring a consistent format. The next chapter is a discussion of the findings from the data summarised.

CHAPTER 5

Discussion of findings

5.1 Introduction

The objectives of the research described in Chapter 1 were linked to the research instruments in Chapter 3. Graphs and tables were used in Chapter 4 to analyse the results from administering the research instrument. The structure used in discussing these results was the same as the structure of the questionnaires.

This chapter provides a discussion of the results from the data analysis, in relation to the previous research reviewed, and secondary data available from the company. This discussion is structured according to the objectives of the study.

The topics covered in this chapter are:

- Objective 1 – The existing manufacturing practices at GUD.
- Objective 2 – Tools that impact productivity improvement.
- Objective 3 – The lean implementation processes that impact on productivity.
- Objective 4 – Employee involvement in lean implementation.

5.2 Objective 1 – The existing manufacturing practices at GUD

To determine if the existing manufacturing practices at GUD were structured to support lean, several questions were included in the questionnaire. The structured interview was also used to gain first hand knowledge of how the implementation was structured.

5.2.1 Lean as a strategy

In establishing a strategy, a company essentially puts together a plan for competing in the marketplace (Reid & Sanders, 2011). It specifies goals, targets and how these will be achieved in order to concentrate on business priorities and is developed by upper management. Using Porter’s generic competitive strategies, a company that wants to adopt a low cost strategy, for example, will focus efforts on reducing costs and improving productivity.

During the structured interviews, all respondents indicated a need to improve as the driver for the lean initiative. There was no formal implementation plan with specific goals and targets. There was also no link established between GUD's strategic objectives and lean. The lean toolbox was to be used to improve the current state of a given operation to improve productivity.

Pettersen (2009) and Burgass (2012) identified four approaches to implement lean, which were summarised in Figure 2.7. One of the approaches, called "Toolbox Lean" was described as a process-oriented approach that focuses on efforts to improve productivity and become lean. Improvements are aimed at achieving some goal or performance target. Other researchers including Radnor *et al.* (2006), Schonberger (2007), Hines *et al.* (2008), Pearce and Pons (2013) and Coetzee *et al*. (2016) also described this type of lean implementation.

"Toolbox Lean" can be used to describe the lean approach observed at GUD. The company started with the implementation of lean in 2010. A cross-functional team put together a customised 5S programme called INONO. In 2014, another cross-functional team developed GPS, a lean toolbox used to apply specific tools to improve productivity and solve problems.

The GUD implementation is vastly different from companies that entrench lean as 'part of their daily work' (Hines *et. al* 2008; Corbett, 2007) or the enterprise-wide lean implementations linked to the long-term strategy described by Pettersen (2009).

Like Emiliani (2008); Radnor and Walley (2008), Pettersen (2009), Burgess (2012) and Coetzee *et al*. (2016) conceded that organisations have different approaches to implement lean. These researchers further acknowledged that the two main types of lean implementations can be described by a focus on lean tools (for productivity improvement) or a focus on 'Lean Thinking' (to improve customer satisfaction).

5.2.2 Lean training

The lean journey is more than the implementation of tools; instead it involves people being given the scope to identify opportunities for improvement by constantly challenging the current way of doing things (Radnor & Walley, 2008). Radnor *et al.* (2006); Schonberger (2007); Pearce and Pons (2013) and Coetzee *et al*. (2016) strongly recommended that employee involvement must be part of the lean implementation process to ensure sustainability and to achieve the full productivity benefits of lean implementation. Schlichting (2009) gathered data on the reasons for lean implementation failures finding that one of the most often featured reasons was the lack of employee involvement (34%).

Employee involvement consists of training employees and involving employees in improvement initiatives (Schlichting, 2009). Cross-training involves giving individuals the skill to perform a variety of tasks so that they can operate different equipment, vary their work content and even perform other types of work which they are not responsible for (Smalley, 2017).

According to Figure 4.6, 43% of employees received less than one hour of training and a total of 30% of employees indicated between one and five hours of training on lean. This finding is common across departments and the majority of respondents had received less than five hours of training, regardless of the level in the organisation. This finding is supported by Figure 4.28 which summarises some of the responses related to standardisation. It is evident from these results that there is also room for improvement in the areas of training on documented procedures.

From the qualitative interviews (Table 4.12) it was established that very little lean training was conducted; however, in some cases subject matter experts were trained and have been deployed to do productivity improvement projects in different areas. This finding is supported by Figure 4.7 which shows there is a peak noted at “more than 20 hours” of training for Production and Quality Engineering. This is in keeping with the findings of Pettersen (2009) who described using ‘subject matter experts’ to ‘get things done’ using isolated projects in companies that have not adopted organisational transformation.

The LEI developed a lean transformation model to help companies achieve successful lean transformation (Figure 2.11). One of the key elements identified by the LEI is Capability Development. This element involves determining how the people at all levels in an organisation need to be developed for the organisation to achieve the productivity improvement required. This element is not clearly evident at GUD.

Employee training is part of employee involvement and employee involvement will be discussed in more detail under Objective 4.

5.2.3 Definition of lean

Researchers generally describe lean from two viewpoints, some focus on the philosophy of waste elimination, and others focus on the tools and techniques used to improve productivity (Shah & Ward, 2007). Pettersen (2009) asserted that there will be variation in the implementation process, based on the fact that there is no consensus about the definition of lean.

Most lean literature focuses on the skills, tools and techniques used to improve productivity and many implementations therefore focus on the tools instead of the customer needs, the strategic business requirements and employee needs (Hines *et al*., 2008). This is in keeping with the toolbox approach described earlier.

The ‘toolbox’ approach is further supported by the results for the definition of lean, illustrated in Figure 4.9, where 47% of respondents defined lean as “Visual Management and INONO”. This finding was common across departments (Figure 4.10) and across roles in the organisation (Figure 4.11). Respondents were able to identify the tools used to improve productivity that form part of lean, but did not understand lean beyond these tools.

In the discussion that follows, the nine bundles of lean tools identified in Chapter 2 are discussed in the context of their implementation at GUD. The discussion under Objective Two will also give further insight into the existing manufacturing practices at GUD.

5.3 Objective 2 – Tools that impact productivity improvement

5.3.1 Tool selection

The “House of Lean” (Figure 2.4) was discussed previously and is meant to describe how all the lean tools fit together (Smalley, 2017). Schlichting (2009) used a ‘Reduced House of Lean’ to describe some lean implementations. Analysis of the survey results suggests a ‘Reduced house of Lean’ can also be used to describe the lean implementation at GUD.

Lean tools are dependent on each other for maximum productivity benefit and sustainability, which is often not appreciated (Herron and Braident, 2007; Coetzee *et al*., 2016). According to the data collected (Table 4.10), the selection of tools forming part of GPS did not follow any scientific methods. Instead, the team identified tools they felt were appropriate for use at GUD to improve productivity and these tools became part of the GPS toolbox.

The results for several questions in the survey suggested further room for improvement. The highest percentage of disagree responses were received for JIT Practices (Figure 4.12), Defects Control (Figure 4.21) and Improvements Strategies (Figure 4.18). These are some of the key areas in lean as they relate directly to the main goals described in the House of Lean, which are highest quality, lowest cost and shortest lead time.

Improvement strategy is related to problem solving which is a direct driver of productivity improvement. The result related to improvement strategies also indicated the absence of key requirements in some areas. Some respondents indicated they do not work with different departments to solve problems and that root causes of problems are not necessarily addressed.

Quality is measured and improved using the improvement strategy. By addressing the root cause, the quality defects can be reduced or eliminated. Respondents indicated that errors are discovered downstream and customer complaints are repeated. This further suggests that the GPS tools are not achieving the objective of solving problems.

These results are an indication that the full productivity benefits of lean are not being achieved and the data suggests that the tools used for GPS are very basic tools and do not address complex or strategic problems. Instead the focus is on short-term or more immediate results.

Figure 4.13 showed numerous respondents indicating that daily targets are not always met (Question 9). This is in keeping with information available on machine stoppages for the assembly department, summarised in Figure 5.1. The graph indicates numerous hours of downtime recorded on equipment. Advanced tools like Total Productive Maintenance and Preventive Maintenance are not used to improve machine downtime.

In contrast, Figure 4.13 also shows the team improves flow of work by eliminating delays (Question 11). This would also require the use and understanding of lean tools. The difference here is that tools applied to eliminate delays will yield short-term results.

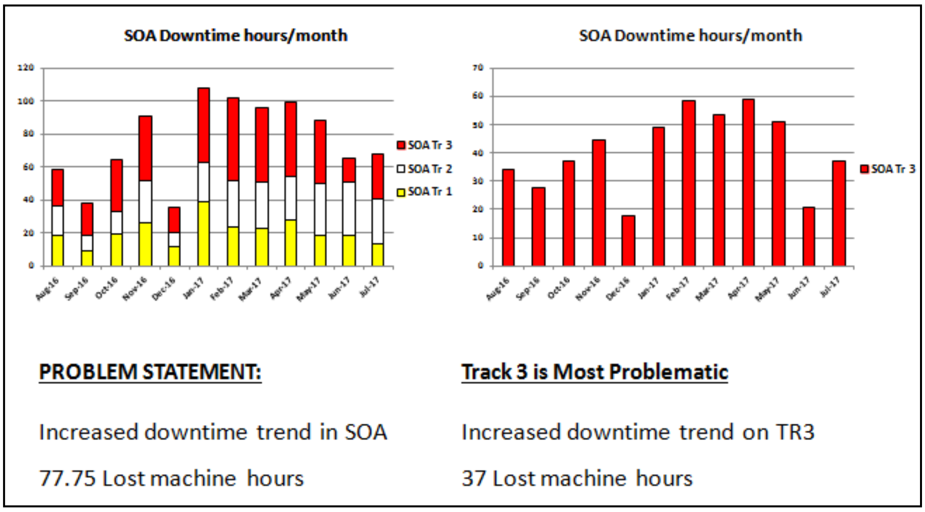


Figure 5.1: Machine stoppage report

Adapted from GUD Holdings. 2017, *Manufacturing Report November* 2017. Durban.

Hines (2012) found that many companies start with the tools in complete isolation of the needs of the customer, the strategic need for change and the needs of their employees. This description closely resembles the "Toolbox Lean" discussed previously.

5.3.2 Application of lean tools

The overall response, across all questions on lean tools, is summarised in Figure 5.2. On average, more than 66% of respondents indicated the presence of these lean tools, whilst 18% were neutral and 14% indicated that these tools were not present. These results suggest some tools are well established; whist there is room for improvement in some areas.

The survey was based on tool categories established by Pettersen (2009) and was selected based on the appearance of these tools in other literature reviewed. Considering the minimum amount of training received by staff on lean, it can be argued that respondents did not know enough about lean to respond to these questions accurately.

This can easily be dispelled by arguing that the design of the questionnaire took into account that people may not have been trained on lean and questions were phrased such that the practices being surveyed could be identified even by people without a detailed understanding of lean.

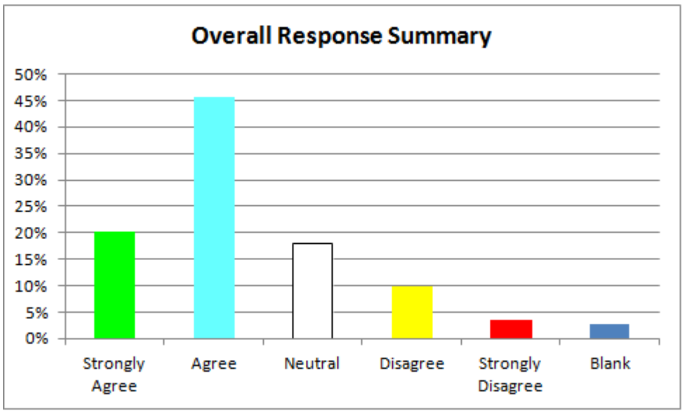


Figure 5.2: Overall response summary from survey

The findings related to each category of tools are discussed further under the category headings.

5.3.2.1 Just-in-time practices

Just-in-time (JIT) is one of the main elements of lean (Womack & Jones, 2003; Liker, 2004) and this is evident in the “House of Lean” (Figure 2.4) as one of the primary pillars consists of just-in-time (Smalley, 2017). Schlichting (2009) discussed the “Reduced House of Lean”, shown in Figure 2.5, finding the primary pillars still consist of just-in-time, even though companies had modified the lean approach. The result from the survey (Figure 4.12 and Figure 4.13) shows a strong JIT presence at GUD, although there are some areas that can be improved.

This finding is also supported by information available from the GUD Cross-functional Team (CFT) Conference held in November 2017. Figure 5.3 is a slide presented at the conference showing the improvement in deliveries of materials to the assembly lines which reduced downtime and improved productivity. The change shown here is moving away from bulk deliveries to delivering components per order and tracking the availability of components visually. The result is smaller more frequent deliveries and reduction in the stock stored in the assembly areas. It must be noted that the last point on the slide identified these actions as part of a larger project to improve line side supply of components, without mentioning lean or JIT.

Figure 5.3: Component delivery improvement

Adapted from GUD Holdings. 2017, *CFT: Manufacturing Process Re-Engineering*. Durban

Another example of improving flow, reducing inventory and improving productivity is summarised in Figure 5.4. This slide describes the movement of the Helix machines manufacturing centre tubes, closer to the point of use of centre tubes. The stock holding of centre tubes reduced by 92% and the value of the stock held dropped by 79%.

The 'Before' picture in Figure 5.4 shows huge volumes of inventory stored in racks, whilst the 'After' picture shows a small quantity of inventory (24-hours supply) staged in front of the machine. This change eliminated some transactions on the information system used, as the centre tubes did not have to be captured as manufactured items, captured as stock receipts in the stores or captured as issues to production from stores. Another productivity improvement was in terms of material handling as these components did not have to be transported long distances.

Figure 5.4 Relocation of helix machine

Adapted from GUD Holdings. 2017, *CFT: Manufacturing Process Re-Engineering*. Durban

The production planning scorecard for three months is shown in Figure 5.5. One of the measures in the scorecard is 'stock control'. The target for the internal component store (ICS) is less than eight days and an improvement can be noted due to the helix machine being moved. In contrast, the stock level in the raw material store (RMS) is over the target of 30 days. This is an example of an area that needs to be improved. Raw materials can be ordered from local suppliers using a pull system (Kanban), where materials are ordered as they are required, and deliveries can be made more frequently and in smaller quantities. This can reduce the stock holding to below target.

PRODUCTION PLANNING AND CONTROL MANAGERS KPI'S 2017/18		TARGET	JUL	AUG	SEP
1 SAFETY	ZERO LOST TIME INJURIES	0	0	0	0
	ZERO REPEAT INJURIES (MINOR OR MAJOR)	0	0	0	0
2 STOCK CONTROL	STOCK LEVEL - ICS	<8 DAYS	5.6	6.5	6.5
	STOCK LEVEL - RMS	<30 DAYS	39.3	38.2	38.2

Figure 5.5: Production planning and control scorecard

Adapted from GUD Holdings. 2017, *Manufacturing Report November* 2017. Durban.

An example of a visual management board is shown in Figure 5.6. Daily team meetings take place around this board where the previous shift's productivity results and the plan for the day are shared with employees. This was confirmed by the results for Question 8, where employees confirmed they knew what the daily production targets are. Figure 5.1 was discussed previously and showed why targets are not always met. This is in keeping with the findings from the survey.

Figure 5.6: Visual management board

Adapted from GUD Holdings. 2017, *CFT: Manufacturing Process Re-Engineering*. Durban.

5.3.2.2 Resource reduction

The term ‘lean’ was originally used to describe a production system that uses fewer resources than traditional production systems. Reducing resources is a central theme in all lean discussions across all literature reviewed. This is evident from Table 2.12 where the appearance of tools in key references was summarised.

Liker and Hoseus (2010) described anything that does not add value as waste, and waste must be eliminated to become more productive. Some of the tools used during resource reduction were also discussed under the same heading in Chapter 2.

The results or the survey showed that 74% of employees surveyed understood the concept of ‘value adding’ activities and their department managed inventory to minimise the amount of stock in the internal component stores.

This is supported by Figure 5.5 where the production planning scorecard for three months showed the inventory level in ICS to be below target. The activities discussed for Figure 5.4 also show the use of small lot production, lead time reduction and inventory reduction.

Another example of resource reduction, taken from the GUD monthly Manufacturing Report for November 2017, is shown in Figure 5.7. Filter elements were discarded at the end of a production run if there were less than 200 elements on the pallet. This practice was stopped as it was not productive and resulted in waste of enormous value.

Small element minimum order quantities (MOQ's) were stored on pallets in ICS and due to the small quantities, up to five item numbers were stored in one location. The double stacking caused damage to the filter elements as well as double handling when searching for an item number. These small quantities were also mixed up with the larger quantities which made it difficult for the operator to find items when required.

In Step 1, the elements were packed in smaller boxes and stored more ergonomically. In Step 2, Tube joint racks were purchased to store the boxes in easily accessible racks and prevent double handling. This creates a dispensary system to manage small quantities of elements and returns from the line.

Figure 5.7: Element dispensary system

Adapted from GUD Holdings. 2017, *Manufacturing Report November* 2017. Durban.

More examples of productivity improvements contributing to resource reduction are discussed under other headings that follow. As with JIT, Figure 5.5 also showed potential for improvement in the RMS area where stock levels are much higher than target. Even the target of less than 30 days can be reduced if lean is applied in this area.

5.3.2.3 Human resources management

One of the keys to success identified by Toyota was investment in its people (Liker & Hoseus, 2010). Employee involvement, team work and cross-training are common themes in most of the research on lean (Liker, 2004; Pettersen, 2009; Schlichting, 2009; Coetzee *et al*., 2016).

More than 78% of respondents in this research indicated the presence of the practices surveyed under human resources management (Figure 4.16). With very low levels of disagree responses, this category shows consistent results across all questions.

The visual management board shown in Figure 5.6 was discussed previously. One of the sheets displayed on the board is called an ILU matrix. This sheet is a table which shows all possible tasks or functions in the department and those people who are able to perform each task, as well as the level of competence in performing the task. This supports the results shown in Figure 4.17 where people stated they were able to perform a variety of tasks in their department.

Table 5.1: Continuous improvement suggestions implemented

	Total	Quality	SMED	INONO	Cost Saving	Rate Improvement	Safety	Maintenance
Canister	13	2	2	1	5		1	2
Centre Tube	1				1			
EFI Extrusion	16	3	2	3		1	5	2
EFI ICM	17	2	4	4	1	1	1	4
EFI Assy	8	1	5	1		1		
EC&V	10	3	1		1	1	2	2
Lids	18	1	11	1		2	2	1
Metal Free	11	3		4	1	2	1	
Multiport	7		1	4				2
Powder Coating	1							1
SOA	17	8	1	2	3		2	1
SOE	6	1		3		1	1	
Waterpump	0							
Other CIs	5	2		2			1	
	130	26	27	25	12	9	16	15

Adapted from GUD Holdings. 2017, *Manufacturing Report November* 2017. Durban.

The information summarised in Table 5.1 was taken from the Monthly Manufacturing report and shows a total of 130 improvement suggestions for the period July 2017 to November 2017. Question 17 and Question 18 of the survey were related to making improvement suggestions and having improvement suggestions implemented. These are examples of employee involvement in improvement and support the findings of the survey.

Toyota has around nine improvement suggestions implemented per employee per year (Power, 2011). In contrast, with 130 improvement suggestions in this period, this amounts to less than two suggestions per employee per year at GUD. This is an area where huge improvement is possible.

Some of the improvements achieved by encouraging work in cross-functional teams are shown in Figure 5.8. The production superintendent, toolmaker, quality engineering technician and production engineering technician were asked to work together in a cross-functional team to address material usage losses. This team identified savings of more than R500 000.

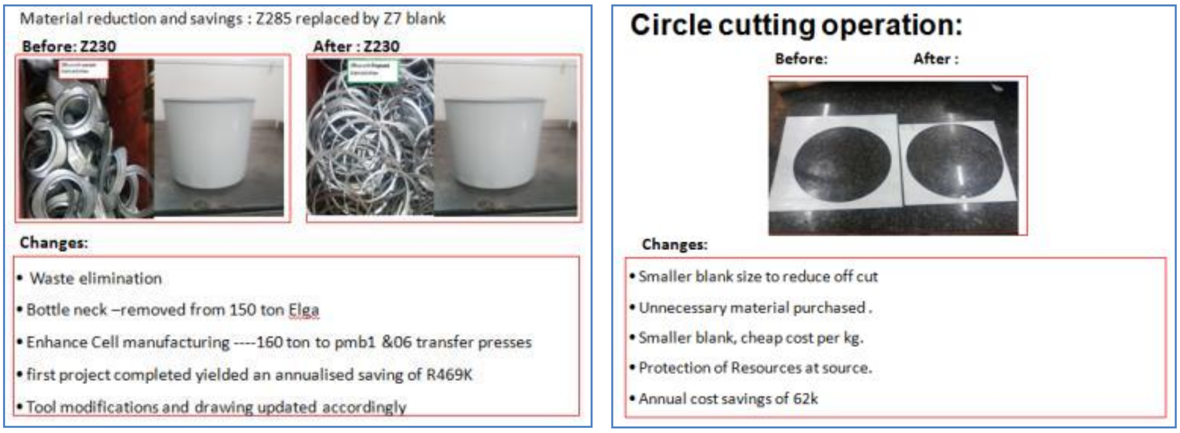


Figure 5.8: Material savings in canister department

Adapted from GUD Holdings. 2017, *CFT: Manufacturing Process Re-Engineering*. Durban.

Although this is an example of a cross-functional team, there was no involvement of employees at operator or supervisor level. All the members of this team are specialists or senior production personnel.

5.3.2.4 Improvement strategies

When researchers discuss continuous productivity improvement, some of the concepts that are discussed are continuous small step improvements (Kaizen), innovations, quality circles and problem solving. Womack and Jones (1990) identified the "continuous improvements that are at the very heart of leanness" being generated "when the system works properly".

The overall result for this category is summarised in Figure 4.18. The majority of the responses indicated the presence of root cause problem solving and teamwork; however, 20% of respondents disagreed or strongly disagreed across all questions. This indicates the presence of areas where these practices are not fully implemented.

One of the key distinctions of continuous improvement is that employees initiate continuous improvement in order to further the company, rather than responding to problems (Womack *et al*., 1990). Problem-solving is one of the drivers of an improvement strategy recently implemented at GUD, shown in Figure 5.9. This strategy was presented at the CFT Conference in November 2017 and was being piloted in one department.

The use of quality circles and formalised problem solving is also evident from Figure 5.9. The difference between these approaches and the improvements discussed in Figure 5.8 is that employees from all levels are involved in this quality circle. The aim of this strategy is to engage all levels in problem solving and use this forum to encourage participation in other continuous productivity improvement activities.

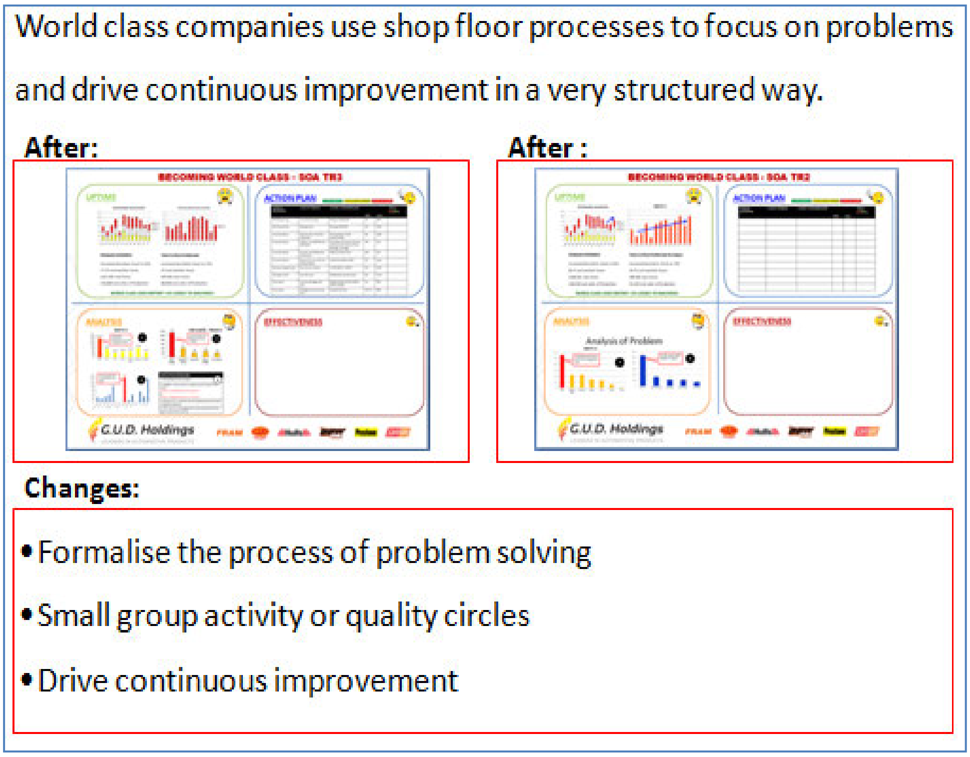


Figure 5.9: Team problem-solving template

Adapted from GUD Holdings. 2017, *CFT: Manufacturing Process Re-Engineering*. Durban.

Another improvement strategy discussed at the CFT was the Durban Quality Strategy. This is shown in Figure 5.10. This strategy was aimed at driving the continuous improvement in quality. One of the activities shown in the action plan is "move all problem-solving to the source / process". This is key to involving everyone in solving the problem and encouraging participation in continuous improvement activities.

The quality strategy identified the current strengths and weaknesses in the business and communicates the quality objective and philosophy to everyone. An action plan is included to establish the finite actions to be implemented and to measure the progress in achieving the strategy.

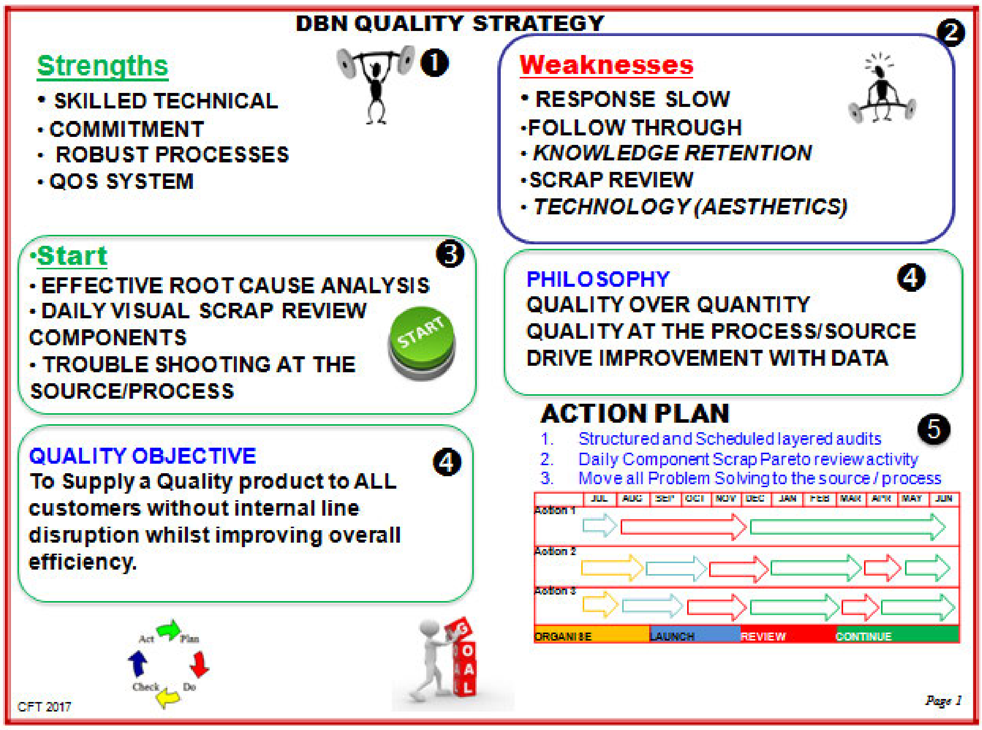


Figure 5.10: Durban Quality Strategy

Adapted from GUD Holdings. 2017, *CFT: Manufacturing Process Re-Engineering*. Durban.

5.3.2.5 Defects control

Defects control is about building quality into the process and product, as one of the rules of the kanban system is to prevent defective parts from being transferred on to subsequent processes (Smalley, 2017). Several tools used to control defects were discussed in Chapter 2.

An example of the impact of the quality strategy is shown in Figure 5.11. Durban experienced customer complaints related to seam leaks after a long period of stability. The increasing trend is evident on the graph in Figure 5.11. A team was put together, including operators, to look into the problem and address the root cause. The intervention of the team was credited with bringing the seam leak complaints down to zero. The team investigated everything from tooling to training and came up with several actions to improve the quality of filters manufactured. The finding of the team was documented in the form of works instructions and training documents so that the intervention is documented and people can be trained on the correct operating practices.

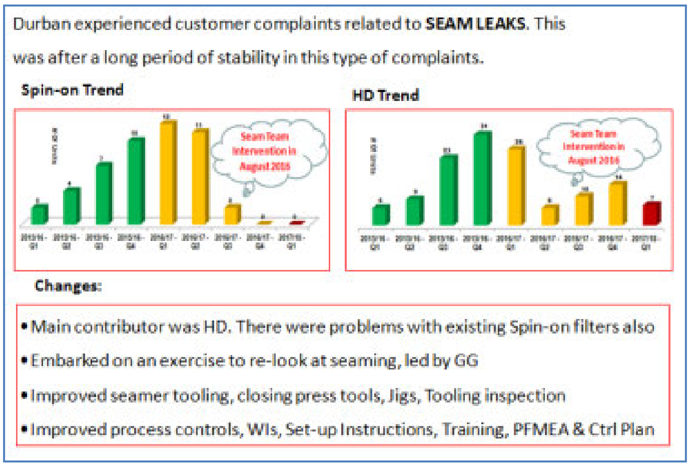


Figure 5.11: Team problem solving for seam leaks

Adapted from GUD Holdings. 2017, *CFT: Manufacturing Process Re-Engineering*. Durban.

Two of the philosophies identified in the quality strategy (Figure 5.10) are 'quality at the process/source' and 'drive improvement with data'. Figure 5.12 shows a quality defect board used to keep track of defects on the shop floor. A majority of the trends on these boards shows a decrease in defects over time.

Figure 5.12: Quality defects boards in Production

Adapted from GUD Holdings. 2017, *CFT: Manufacturing Process Re-Engineering*. Durban.

The results of the survey show that more than 48% of respondents indicated that the principles related to defect control are in place. There was also a high number (27%) of respondents indicating a lack of this approach. The quality strategy also identifies some weaknesses in the current approach, including 'slow response' and 'knowledge retention' which supports the findings from the survey.

5.3.2.6 Supply chain management

Lean focuses on the supply chain and identifies internal operations as part of a larger value stream, starting at suppliers and ending at the customer (Pettersen (2009). Lean encourages helping business partners to grow (Liker, 2004).

The quality assurance department at GUD works with suppliers and develops suppliers with a focus on improving the quality of the products supplied. Supplier development engineers are sent to suppliers to investigate and address supplier problems. The focus of the survey was on the interaction with the customers that form part of the supply chain.

Over 70% of employees indicated these practices were present at GUD. A majority of the respondents indicated they understood what customers expect and their department had made improvements by changing processes.

In contrast, some employees indicated poor communication with suppliers and poor handling of customer complaints. This is very likely an indication of problems with communication within the organisation rather than with customers, as Figure 5.11 is an example of how the company deals with customer complaints. Figure 5.12 also shows communication about internal process defects and internal supplier defects, but no customer complaint information.

5.3.2.7 Standardisation

Standardisation in a process is used to ensure reduced variation and repeatability of results. This is key to identifying deviation and ensuring consistent quality (Smalley, 2017).

Figure 5.13 shows an example of standardised work being documented and displayed on the assembly lines in order to reduce variation and ensure consistent quality. The following three documents are displayed on every workstation:

1. Work Instruction – used for training of operators and documents operations.
2. Process Flow – breaking down the activity into individual steps.
3. Standardised work – showing the step-by-step movement to perform the task.

These documents are implemented in some areas and are work in progress in others. The results of the survey show this, as Question 33 showed a peak of people disagreeing that they had received training on documented procedures.

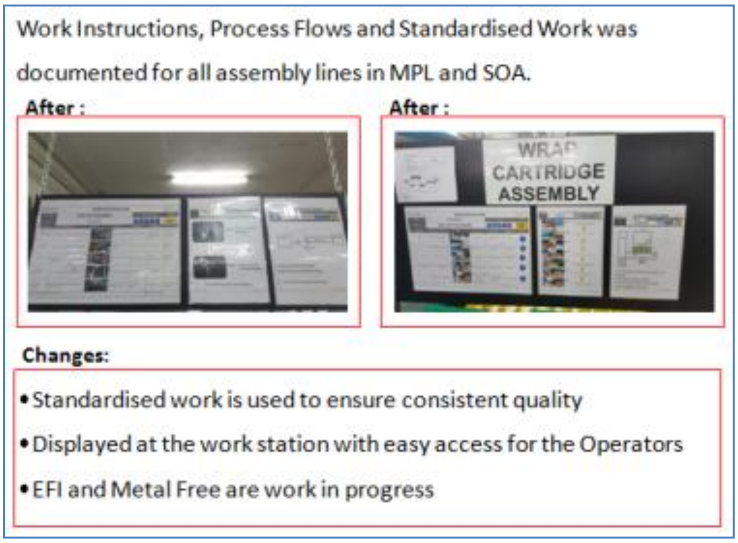


Figure 5.13: Standardised work

Adapted from GUD Holdings. 2017, *CFT: Manufacturing Process Re-Engineering*. Durban.

Another example of standardised work is shown in Figure 5.14. Tooling was stored in a disorganised manner in cupboards. The storage of tooling was upgraded and some of the benefits realised were improved changeover times, improved accessibility and the new storage method also reduced tool damage. Question 31 of the survey showed people agree that their workplace is well organised.

Figure 5.14: Tool storage board

Adapted from GUD Holdings. 2017, *CFT: Manufacturing Process Re-Engineering*. Durban.

Question 34 and Question 35 focused on visually tracking team performance and discussing team performance on a daily basis. Figure 5.6, discussed previously, showed an example of a visual management board used to track performance and where teams met to discuss performance. It must be noted that the responses to these questions indicated team performance was not discussed on a daily basis. This is because some teams meet weekly.

5.3.2.8 Scientific management

The scientific management approach is largely credited to Frederick Taylor and includes such tools as time and motion study, and work standards (Jones and George, 2009). The lean approach that forms part of the scientific management tools includes multi-manning, workforce reduction and layout adjustments (Smith, 2011).

The quality strategy (Figure 5.10) includes 'drive improvement with data' as one of the three philosophies to improve quality. This is an example of scientific management. Decisions are governed by data that is collected from the process and improvement is measured by monitoring the same data. Another example of this is evident in Figure 5.9, where the problem-solving approach is also driven by certain measures that are tracked on the problem-solving template.

Figure 5.15 shows an improvement on the EFI line, where the layout and process was changed to increase the output to match the assembly line speed. This balanced the line and decreased the labour usage. This was achieved using scientific management tools.

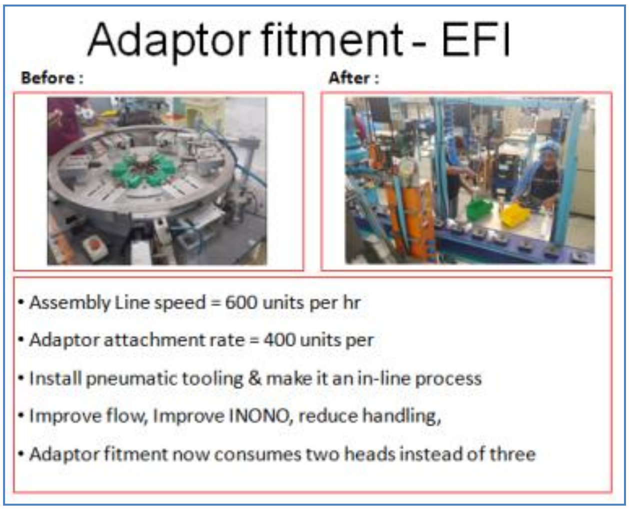


Figure 5.15: Adaptor process in EFI

Adapted from GUD Holdings. 2017, *CFT: Manufacturing Process Re-Engineering*. Durban.

The circle cutting operation is shown in Figure 5.16. This operation used five workers and built inventory between processes as the line was not balanced. By balancing the workload between operations (using time and motion studies), the inventory was reduced and the process now requires four workers to complete the job.

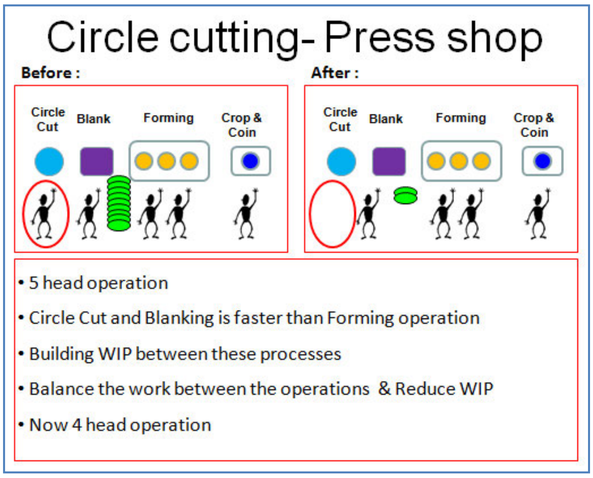


Figure 5.16: Circle cutting process in Press shop

Adapted from GUD Holdings. 2017, *CFT: Manufacturing Process Re-Engineering*. Durban.

Another example of scientific management is shown in Figure 5.17. Two different jobs were combined and completed by one person. This was achieved by changing to the layout and retraining the affected personnel. The labour utilised in this operation was reduced by one person.

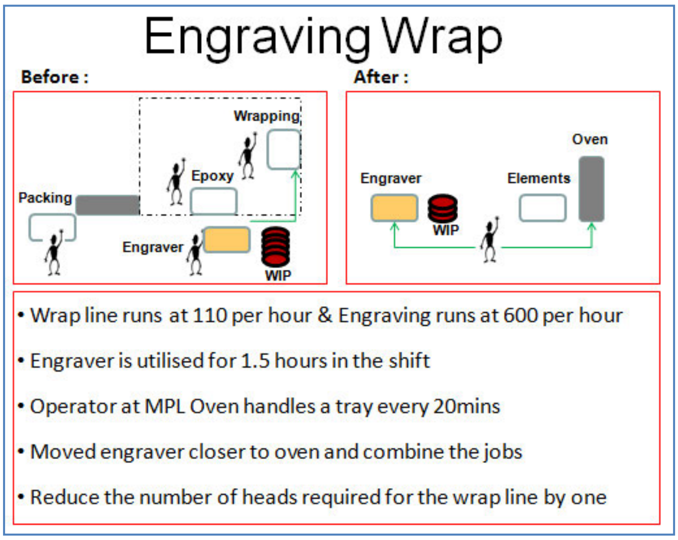


Figure 5.17: Engraving process in Wrap

Adapted from GUD Holdings. 2017, *CFT: Manufacturing Process Re-Engineering*. Durban.

This evidence from the company supports the finding of the survey with 64% of respondents indicating the presence of these methods. Considering the departments involved in the survey, 22% of respondents (Technical 6%, Engineering Services 5%, Warehouse 11%) may not be directly involved in these types of activities. This suggests a very high 'agree' response rate amongst the workers impacted in this category.

5.4 Objective 3 – The lean implementation processes that impact on productivity

Some researchers advise that lean implementation needs to be customised to the specific needs of the company (Corbett, 2007; Pettersen, 2009), whilst others argue that adapting lean results in confusion, and not realising maximum productivity benefits and sustainability (Herron & Braident, 2007; Coetzee *et al*., 2016). According to Pearce and Pons (2013), understanding what lean tools to implement and how to implement them is key to achieving lean success.

The LEI (2017) found that each organisation's lean journey is unique and one cannot just copy what was done elsewhere. Several lean implementation processes were discussed in Chapter 2.

5.4.1 Lean as a strategy

The House of Lean (Figure 2.4) was discussed in Chapter 2 and according to Schlichting (2009), the diagram is meant to represent the dependence of the components of lean on each other. Most lean articles ignore this dependence of components and discuss the tools on their own. This has led readers to believe that the tools can be independently applied to solve problems or improve productivity (Schlichting, 2009).

This independent approach or toolbox approach, with no link to the organisational strategy, observed at GUD is not recommended, with several researchers warning that such implementations are flawed (Radnor *et al.*, 2006; Schonberger, 2007; Pearce and Pons, 2013; Coetzee *et al*., 2016). Emiliani (2013) also concluded that companies implementing lean as a toolbox do not see lean as a method for addressing customer needs and removing waste, and their failure to understand the meaning of lean is the main reason for implementation failures. These authors recommend that employee involvement and customer focus must be part of the lean implementation process to ensure sustainability and to achieve the full productivity benefits of lean implementation.

Radnor *et al.* (2006) and Radnor and Walley (2008) in their research of lean implementation reported on an approach to lean linked to the long-term strategy of the organisation. This was achieved by adopting a complete systems view to lean implementation similar to the original implementation model at Toyota. More recently, Coetzee *et al*. (2016) described this type of implementation developed to assist organisations to transform into lean enterprises. Some of the key elements (Table 2.14) include building a vision, and establishing goals and metrics, which are aligned to strategic planning.

Emiliani (2008), Radnor and Walley (2008), Pettersen (2009), Burgess (2012), Coetzee *et al*. (2016) and many other researchers conceded that organisations have different approaches to implement lean. These researchers further acknowledged that the two main types of lean implementations can be described by a focus on lean tools (for productivity improvement) or a strategic approach (to improve customer satisfaction). Emiliani (2008) very bluntly described the toolbox lean approach as “fake lean” which is most likely to fail and the strategic approach as “real lean”, which is most likely to succeed.

Although there is no clear link between GUD strategy and lean implementation, some of the strategic lean tools are evident in GUD operations. JIT is one of the key components of lean shown in the House of Lean (Figure 2.4) and 67% of respondents (Figure 4.12) indicated the presence of these practices. Most of the essential components of JIT (production levelling, processing using continuous flow and takt time) currently exist at GUD.

5.4.2 Respect for people

Definitions of lean generally focus on the philosophy of waste elimination or on the tools and techniques (Shah & Ward, 2007). The variation in lean implementation processes can be attributed to the lack of consensus about the definition of lean (Petersen, 2009). Many implementations do not focus on the customer needs, the strategic business requirements and employee needs (Hines *et al*., 2008).

On way of addressing employee needs is by showing respect for people. The ‘Toyota Way Model’ replicated in Figure 2.9 shows the reliance of people in TPS (Coetzee *et al*., 2016). Figure 2.9 is meant to represent how respect for people is built on respect and teamwork. Respect is shown by asking an employee to contribute to solving a problem, and teamwork is used to help people develop and to maximise productivity improvement. The LEI (2017) describes respect for people being demonstrated by cross training, promoting teamwork and encouraging people to achieve their potential by increasing responsibility and authority.

Question 14 to Question 19 in the questionnaire administered to staff, dealt with human resource management. All responses in this category are summarised in Figure 4.16. A total of 78% of respondents agreed (51%) or strongly agreed (27%). This shows a presence of practices like cross training employees, involvement of employees and emphasis on teamwork. These are all required in order to demonstrate respect for people.

Several questions (Question 20 to Question 22) in the questionnaire dealt with improvement strategies. These results also demonstrate how teamwork and problem solving with cross functional teams is used to improve performance. The overall result in this category is summarised in Figure 4.18. More than 55% of respondents agreed or strongly agreed, whilst 20% either disagreed or strongly disagreed.

Even though the majority of responses indicate the presence of principles related to improvement strategy, there seem to be 'pockets of excellence' within GUD. Some areas have the principles in place, whilst some areas have not fully implemented the approach.

Both tools discussed above contribute to the respect for people required as part of lean implementation to improve productivity.

5.4.3 Continuous improvement

When researchers discuss continuous improvement, some of the concepts that are included are continuous small step improvements (Kaizen), innovations, quality circles and problem solving. Womack and Jones (1990) identified the "continuous improvements that are at the very heart of leanness" being generated "when the system works properly". One of the key distinctions of continuous improvement is that employees initiate continuous improvement in order to further the company, rather than responding to problems (Womack *et al*., 1990).

The 'Toyota Way Model' replicated in Figure 2.9 identifies continuous improvement as another key building block in the TPS (Coetzee *et al*., 2016). This pillar is supported by the following:

- Challenge – Form a long-term vision (Strategy).
- Kaizen – Improve operations continuously.
- Genchi Genbutsu – Go to the source or ‘go and see for yourself’.

Continuous improvement was included in the discussion on the application of some lean tools (5.3.2) and some of the key points are summarised below.

5.4.3.1 Resource reduction

The term ‘lean’ was originally used to describe a production system that does more with fewer resources. This is achieved by eliminating anything that does not add value to the customer (Liker & Hoseus, 2010).

Projects discussed under JIT (Figure 5.3 and Figure 5.4) and Resource Reduction (Figure 5.7) show examples of improvements driven by problem solving. Although these are called continuous improvement projects, they do not show continuous improvement initiated by employees in order to further the company.

These projects are executed by subject matter experts and there is very little employee involvement. Employees are trained in the new system as part of the implementation.

5.4.3.2 Human resource management

Toyota identified investment in its people as one of the keys to success (Liker & Hoseus, 2010). Employee involvement, team work and cross-training are common themes in most of the research on lean (Liker, 2004; Pettersen, 2009; Schlichting, 2009; Coetzee *et al*., 2016).

A total of 130 improvement suggestions were submitted by employees for the period July 2017 to November 2017 (Table 5.1). These are examples of continuous improvement initiated by employees in order to further the company. This is supported by the findings of the survey where Question 17 and Question 18 were related to making improvement suggestions and having improvement suggestions implemented. These questions had positive response rates above 70%.

Toyota has around nine improvement suggestions implemented per employee per year (Power, 2011). In contrast, with 130 improvement suggestions in the period mentioned, this amounts to less than two suggestions per employee per year at GUD. This is an area where huge improvement is possible.

Some of the improvements achieved by encouraging work in cross-functional teams are shown in Figure 5.8. A cross-functional team was used to address material usage losses. This team identified savings of more than R500 000.

Although this is an example of a cross-functional team, there was no involvement of employees at operator or supervisor level. This is another example of continuous improvement projects derived by problem solving and managed by subject matter experts.

5.4.3.3 Improvement strategies

Improvement strategies consist of continuous small step improvements (Kaizen) and innovations (Beyond Lean, 2017). An improvement strategy is related to problem solving which is a direct driver of continuous improvement.

The result related to improvement strategies, summarised in Figure 4.18, indicated the absence of key requirements in some areas. Some respondents indicated they do not work with different departments to solve problems and that root causes of problems are not necessarily addressed, resulting in repeat quality defects.

Quality is measured and improved using the improvement strategy. By addressing the root cause, the quality defects can be reduced or eliminated. Similar findings to improvement strategy are also observed for defects control which is summarised in Figure 4.21 and Figure 4.22. Respondents indicated that errors are discovered downstream and customer complaints are repeated. This further suggests that the GPS tools are not achieving the objective of solving problems and driving continuous improvement in some areas. This is in keeping with the findings of the qualitative interview (Table 4.12) where subject matter experts were trained and deployed to do projects in some areas; whilst training was minimal in other areas.

The use of quality circles and formalised problem solving is evident from Figure 5.9 where employees from all levels are involved in the improvements. The aim of this strategy is to engage all levels in problem solving and use this forum to encourage participation in other productivity improvement activities.

These are more examples of continuous improvement projects derived by problem solving and managed by subject matter experts; although it must be stated that there is a much greater component of employee involvement in these projects.

5.4.3.4 Defects control

Defects control is about building quality into the process and product, as one of the rules of the kanban system is to prevent defective parts from being transferred on to subsequent processes (Smalley, 2017).

One of the improvement strategies discussed previously is the Durban Quality Strategy. This is shown in Figure 5.10. This strategy was aimed at driving the continuous improvement in quality. Two of the philosophies identified in the quality strategy are 'quality at the process/source' and 'drive improvement with data'. Figure 5.12 shows a quality defect board used to keep track of defects on the shop floor. Most of the trends on these boards show a decrease in defects over time.

The results of the survey show that more than 48% of respondents indicated that the principles related to defect control are in place. There was also a high number (27%) of respondents indicating a lack of this approach. The quality strategy also identifies some weaknesses in the current approach which supports the findings from the survey.

An example of the impact of the quality strategy is shown in Figure 5.11. Durban experienced customer complaints related to seam leaks after a long period of stability. The increasing trend is evident on the graphic in Figure 5.11. A cross-functional team was put together, including operators, to look into the problem and address the root cause. The intervention of the team was credited with bringing the seam leak complaints down to zero.

5.4.3.5 Scientific management

The scientific management approach includes such tools as time and motion study, and work standards (Jones and George, 2009). The lean approach that forms part of the scientific management tools includes multi-manning, workforce reduction and layout adjustments (Smith, 2011).

The quality strategy (Figure 5.10) includes 'drive improvement with data' as one of the three philosophies to improve quality. This is an example of scientific management. Decisions are governed by data that is collected from the process and improvement is measured by monitoring the same data.

Numerous examples (Figure 5.15, Figure 5.16 and Figure 5.17) were discussed where these methods are used in continuous improvement, with the survey showing 64% of respondents indicating the presence of these methods. These are also examples of continuous improvement projects derived from problem solving and managed by subject matter experts.

5.5 Objective 4 – Employee involvement in lean implementation

Embedding a culture that encourages employee involvement in an organisation is a prerequisite for the implementation of lean (Radnor & Walley, 2008). Employee involvement includes training of employees and involving employees in improvement initiatives (Schlichting, 2009). Burgess (2012) noted tools that allow an employee to stop the production line when defects are detected, as an indication of how important an employee is to the TPS.

This view is supported by various researchers including Liker (2004) and more recently by Coetzee *et al*. (2016:81) who argued that TPS is not a toolbox, but a system that encourages people to continually improve all aspects of their daily work. These researchers further declared that “people are the centre of the TPS house”.

5.5.1 Lean training for employee involvement

The most often featured reason for lean failures is the lack of employee involvement. A Toyota executive is credited with declaring that in order to build cars, Toyota first builds people. Lean is highly dependent on the involvement of people and some authors define lean as an approach that provides tools for people to continually improve productivity (Liker, 2004).

In support of this, Spear and Bowden (1999) found that companies using TPS believed people are the most important corporate asset. Their research also found that companies invest in the knowledge and skills of employees in order to become more competitive. Other researchers (Liker, 2004; Radnor & Walley, 2008; Schlichting, 2009; Hines, 2012) also identified the involvement of people as a key requirement for the successful implementation of lean.

In contrast, it was evident from the response to Question 6, summarised in Figure 4.6, that this was not the approach implemented at GUD. More than 73% of employees indicated they received less than five hours of lean training, whilst 43% of respondents received less than one hour of training. This finding was consistent across departments (Figure 4.7) and across roles in the organisation (Figure 4.8).

The only exception was noted for Production and Quality Engineering where the hours of training received peaked at more than 20 hours. This suggests the approach at GUD is similar to those described by Supply Chain Digest (2013) as "a small group of specialists who work in isolation, with little support from management, and little understanding from shop floor personnel".

This is further evident from the structured interview, Table 4.12. It was acknowledged that training was minimal and on the job training was done in some areas. One respondent noted that in some cases, subject matter experts were trained and deployed to do projects in different areas.

Some of the projects completed by the subject matter experts and different cross-functional teams were included in the discussion of Objective 2 and Objective 3. There was no involvement of employees at operator or supervisor level on most projects managed by subject matter experts. The use of quality circles where employees from all levels are involved was also evident in some areas, however; these teams also did not receive any formal training.

5.5.2 Teamwork

One of the main reasons for training people is to have employees working in teams to achieve common goals, and allowing employees to be involved in solving problems that have an impact on their work (Liker, 2004; Schlichting, 2009).

Coetzee *et al*. (2016) used "The Toyota Way" model to explain the reliance of people in TPS with 'Respect for People' being a major component for the Toyota Way. Respect for people is built on respect and teamwork. Respect is shown by asking an employee to contribute to solving a problem, and teamwork is used to help people develop and to maximise performance.

Numerous questions related to teamwork were included in the survey and the results for these questions are summarised in Table 5.2. The majority of the questions had more than 70% positive responses.

Table 5.2 Summary of questions on teamwork

No.	Question	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagre	Blank
11	My team improves the flow of work by eliminating delays.	12%	67%	12%	6%	1%	2%
17	My team discusses how to improve customer satisfaction.	27%	50%	14%	5%	5%	0%
18	My team makes suggestions for improvement	27%	48%	17%	5%	3%	0%
19	My team has had improvement suggestions implemented.	17%	53%	22%	6%	1%	1%
20	In the past two years we have solved many problems through teamwork.	18%	34%	27%	8%	6%	6%
21	I join teams from different departments to help solve problems.	14%	39%	20%	16%	9%	2%

The responses to Question 20 and Question 21 included lower positive responses and higher negative responses in comparison to other questions on teamwork. These two questions were specifically aimed at determining the use of problem-solving teams and cross-functional teams. These results indicate that teamwork is not implemented in all areas at GUD.

This finding is in keeping with data collected from the qualitative interview (Table 4.12) where training on lean varied from training subject matter experts to no training in some areas. This explains the inconsistency in how lean is implemented in different departments.

The toolbox approach to lean described by Pettersen (2009) is used by 'subject matter experts' to 'get things done' using isolated projects with defined start and end dates. In contrast, every other lean implementation process is described as having a vision, empowering employees and teamwork. Most authors strongly recommend that employee involvement including teamwork should be part of the lean implementation process to ensure sustainability and to achieve the full productivity benefits of lean implementation.

5.6 The benefits realised from lean implementation

There were two questions in the structured interview that dealt with the expectations and progress of lean at GUD. The first question (Question 5) was based on the expected outcomes and respondents indicated no milestones were established and there was also no quantification of the expected outcomes.

The second question (Question 6) was aimed at determining if GPS achieved the required objectives. Respondents did not have milestones to measure against, so could not quantify the results. However, respondents did agree that there were productivity improvements.

Table 5.3 and Table 5.4 were presented at the CFT in November 2017. These tables listed all the projects that had been completed or were in progress and summarised the savings targeted or achieved by these projects. Table 5.3 lists all the completed projects (some of which were discussed previously) along with the savings already achieved. GUD achieved savings of R2,135,000 by implementing lean projects in 2017.

Table 5.3 Total savings achieved for 2017 (CFT, 2017)

ITEM	PROJECT	SAVINGS
1	Unbalanced Equaliser	578,000
2	Move from Z285 blank to Z7, move Z222 to Z91	469,000
3	Reduction of zeta coat in PC	155,000
4	Move Helix to ICS	152,000
5	EFI Lids on Robo Drill	118,000
6	Reduction of Heads and OT in Wrap	114,000
7	5% Chemical cost savings	87,000
8	HD Canister - Remove circle cutter head	80,000
9	MPL - Packing head	80,000
10	SOE - Top end cap conveyor	80,000
11	Controls on Cell 5 Press - Light curtains	80,000
12	EFI Assembly - Adaptor process - lin line	80,000
13	Circle cut blank size reduction	62,000
	Total achieved FYTD	**2,135,000**

Adapted from GUD Holdings. 2017, *CFT: Manufacturing Process Re-Engineering*. Durban

Table 5.4 lists all the projects that are currently in progress or under investigation as well as the potential savings that can be achieved by implementing these projects. The total of R2,355,000 represents the savings potential of current lean projects.

Table 5.4 Total potential savings in progress (CFT, 2017)

ITEM	PROJECT	SAVINGS
14	Skip cutting on Metal Free Pleating	240,000
15	SOA Element supply to the line in trays	240,000
16	RMS - Forklift reduction	167,000
17	Form fill & seal	160,000
18	EFI Extrusion autofeeder	160,000
19	RMS - Incoming & put aways and bar coding	160,000
20	Hand fed to roll form (5086, 5091)	135,000
21	Handfed seal retainers to progression	135,000
22	Sol braze 4 parts	120,000
23	Powder coat fracture elimination (IR)	96,000
24	New Bubba seamer in MPL	81,000
25	Bibra headcount moving Op to a washer	80,000
26	SOA T2 - Bowl Feeder	80,000
27	EFI Assembly - IR Pre-gel	80,000
28	SOE - Automation of valve to end cap assembly	80,000
29	Robotic feeding of the bibra	80,000
30	A0 Becoming world class	68,000
31	SOA TR3 Change parts storage	64,000
32	Powder coat fracture elimination (IR)	51,000
33	Hydraulic clamping of tools - SMED - EFI	45,000
34	HD Lids on PMB welder	33,000
	Total potential	**2,355,000**

Adapted from GUD Holdings. 2017, *CFT: Manufacturing Process Re-Engineering*. Durban

Womack *et al*. (1990) found Japanese factories using lean "requires one half the effort of the American luxury-car plants, half the effort of the best European plant and a quarter of the effort of the average European plant". It is therefore suggested that the savings potential at GUD far exceeds the amounts shown in the above tables.

5.7 Key findings related to the research objectives

The aim of this study was to look at the factors that affect implementation of lean manufacturing to improve productivity. The objectives of this study were formulated in order to address the research question. Table 5.5 below summarises the findings related to each research objective to show how each of the objectives have been addressed.

Table 5.5 Findings related to objectives

Section	Objective	Findings
5.2	To assess the existing manufacturing practices of GUD	
5.2.1	Lean as a strategy	There was no link established between GUD's strategic objectives and lean implementation.
5.2.2	Lean Training	Lean training was limited with 43% of employees receiving less than one hour of training. Subject matter experts were trained and deployed to do projects in some areas.
5.2.3	Definition of Lean	Respondents were able to identify lean tools with 47% of respondents defining lean based on the tools they are familiar with.
5.3	To identify the lean manufacturing tools that impact on productivity improvement at GUD.	
5.3.1	Tool Selection	The selection of tools forming part of GPS did not follow any scientific methods.
5.3.2	Application of Lean tools	The highest percentage of agree responses were received for Human Resource Management (79%), Resource Reduction (74%) and Supply Chain Management (70%).
		The highest percentage of disagree responses were received for Defects Control (27%), Improvements Strategies (20%) and JIT Practices (14%).
		The tools used for GPS are very basic tools. These tools are used focus is on short-term results.
5.4	To identify the lean manufacturing implementation processes that impact on productivity improvement at GUD.	
5.4.1	Lean as a Strategy	Although there is no clear link between GUD strategy and lean implementation, some of the strategic lean tools like JIT are evident in GUD operations. A majority of participants agree (50%) or strongly agree (17%) with questions related to JIT.
5.4.2	Respect for People	Practices like cross training employees, involvement of employees, emphasis on teamwork and some problem solving with cross-functional teams are also present. There is evidence of 'pockets of excellence' within GUD
5.4.3	Continuous Improvement	Examples of improvement projects derived from problem solving and managed by subject matter experts were evident. Employee initiated continuous improvement was evident at less than 2 per year per employee compared to 9 per year per employee at Toyota.

Table 5.5 Findings related to objectives (continued)

Section	Objective	Findings
5.5	To determine how employee involvement in lean implementation enhances productivity at GUD.	
5.5.1	Lean training for Employee Involvement	Lean training was limited with 43% of employees receiving less than one hour of training. Subject matter experts were trained and deployed to do projects in some areas.
5.5.2	Teamwork	Majority of the questions on teamwork had more than 70% positive responses. There were higher percentages of negative responses for questions on the use of problem solving teams (14% Disagree) and cross-functional teams (25% Disagree).

As demonstrated in Table 5.5, there were numerous findings relating to the objectives of the study. By meeting the objectives of the study, the research question can be answered. This is addressed in the next chapter along with the conclusion and recommendations.

5.8 Chapter summary

This chapter was a discussion of the findings from both the structured questionnaire and the structured interviews. The data collected was compared with the literature reviewed as well as secondary data from the company. Several examples of lean projects were identified and discussed.

The discussion of findings was structured according to the objectives of the study, with several findings being documented. These findings were supported by literature reviewed and secondary data. A summary of the findings shows how the research objectives were achieved.

The next chapter presents the conclusions and recommendations that originated from the discussion of findings.

CHAPTER 6

Conclusions and recommendations

6.1 Introduction

Local companies in the automotive industry are looking at ways to improve productivity and lean manufacturing is an approach to production that promises to deliver improved productivity. The aim of this study was to look at the factors that affect implementation of lean manufacturing to improve productivity at GUD. The objectives of this study were formulated in order to address the research question and a cross-sectional study was conducted at GUD to gather data required for the study. The data was analysed and Chapter 5 presented a discussion of the findings. This chapter provides the conclusions derived from the study and recommendations linked to the findings of the study. The chapter concludes with recommendations for future research.

6.2 Conclusions

The findings discussed in the previous chapter indicated that there is room for improvement in the current lean implementation processes at GUD, in order to maximise productivity. The conclusions discussed below are derived from the literature review and from the data gathered via the surveys. Each of these conclusions is discussed further.

6.2.1 Lean as a strategy

The LEI (2017) found that each organisation's lean journey is unique and one cannot just copy what was done elsewhere. Four broad approaches used to implement lean were identified from the literature review. These four approaches were divided into Toolbox Lean, Leanness, Becoming Lean and Lean Thinking.

These approaches included using a lean toolbox to 'get things done' with isolated projects; applying some of the tools to predefined problems; focusing on continuous efforts to achieve some goal or performance target and embedding lean as 'part of their daily work' whilst focusing on the philosophy of lean thinking. The Toolbox Lean approach is used to focus on short-term results, with low investment; whilst a ‘Full Implementation’ will be linked with strategy and requires a complete change of culture.

Many researchers (Emiliani, 2008; Radnor & Walley, 2008; Pettersen, 2009; Burgess, 2012; Coetzee *et al*., 2016) conceded that organisations have different approaches to implement lean. These researchers further acknowledged that the two main types of lean implementations can be described by a focus on lean tools (for productivity improvement) or a focus on ‘Lean Thinking’ (to improve customer satisfaction).

In 2014, a the GUD cross-functional team (CFT) put together a programme called GUD Productivity System (GPS). The aim of GPS was to achieve manufacturing process and productivity improvement by applying some lean tools. The focus of the team was more around presenting the GPS programme at the CFT management conference, rather than the long-term strategic benefits that could be realised by lean implementation. There was no formal implementation plan and there is no link between GUD’s strategic objectives and GPS. The lean implementation at GUD can be described as Toolbox Lean. Although there is no clear link between GUD strategy and lean implementation, some of the strategic lean tools like JIT are evident in GUD operations.

6.2.2 Application of lean tools

One of the concerns with lean implementations is that the tools are dependent on each other for maximum benefit and sustainability, which is often not appreciated. The House of Lean is used to document the major components of the Toyota Production System (TPS), as well as the key methods and tools. According to Schlichting (2009), the diagram is meant to represent the dependence of the components on each other. Schlichting (2009) also found that most lean literature focuses on the explanation of tools, giving the reader the impression that the tools can be used at any time to treat specific problems or gain productivity improvements.

Lodgaard *et al* (2016) warned that excessive focus on tools is one of the causes of lean failures and will have negative effects on business performance over time. Coetzee *et al*. (2016) found that companies implementing lean tools realise benefits in the short term, but will never achieve the full productivity benefits that these tools offer, unless they understand the entire system. The practice of selecting some tools to implement is not necessarily bad, but the results are limited. At GUD, the selection of tools did not follow any scientific methods. The CFT identified tools they felt were appropriate for use at GUD and these tools became part of the GPS toolbox.

The CFT was responding to a request by senior management to address productivity and process improvement. Some members of the team had experience in lean and moved the team in this direction. The team then used the internet to identify commonly used lean tools in production and some members of the team had their own information on lean.

Some lean tools related to Human Resource Management, Resource Reduction, Supply Chain Management, Defects Control, Improvements Strategies and JIT Practices are embedded in GUD operations. In general, there is inconsistency in the way tools are applied in different areas of GUD. The full productivity benefits of lean are therefore not being achieved. These tools are not used to address complex or strategic problems, instead; the focus is on short-term or more immediate results.

6.2.3 Definition of lean

The terms Toyota Production System, Lean, Lean Thinking, Lean Production and Lean Manufacturing, were discussed in Chapter 2. Researchers generally describe lean from two main viewpoints. Some focus on the underlying philosophy of waste elimination, and others focus on the practical application of tools and techniques. Researchers have found variations in the implementation process, based on the fact that there is no consensus about the definition.

Most lean literature focuses on the skills, tools and techniques and many implementations therefore focus on the tools instead of the strategic business requirements. Most employees at GUD were able to identify the tools that form part of lean, but did not understand lean beyond these tools. These employees have an understanding of what is already present at GUD, but not a greater understanding of where it fits into lean.

6.2.4 Lean training

As part of lean transformation for productivity improvement, one of the key elements is capability development (LEI, 2017). This element involves determining how the people at all levels in an organisation need to be developed for the organisation to achieve the improvement required. At GUD, subject matter experts were trained to 'get things done' using projects. This is typical in companies that have not adopted organisational transformation.

Employee involvement includes employee training and cross-training involves giving individuals the skill to perform a variety of tasks. It is evident from the results of the study that there is room for improvement in the areas of training and capability development.

6.2.5 Continuous improvement

Womack and Jones (1990) identified the "continuous improvements that are at the very heart of leanness" being generated "when the system works properly". One of the key distinctions of continuous improvement is that employees initiate continuous improvement in order to further the company, rather than responding to problems. There were numerous examples of improvements driven by problem solving. These projects were executed by subject matter experts and there was very little employee involvement. Even when cross-functional teams were used, most of these teams had no involvement of employees at operator or supervisor level.

There were examples of continuous improvement initiated by employees and the use of quality circles with formalised problem solving involving employees from all levels. These were not the norm and majority of employees do not work with different departments to solve problems and root causes of problems are not necessarily addressed, resulting in repeat quality defects.

6.2.6 Employee involvement

Despite the emphasis put on people involvement in lean, one of the leading reasons cited for lean failures is the failure to engage people (Coetzee *et al*., 2016). Spear and Bowen (1999) confirmed that all of the organisations using the TPS "share an overarching belief that people are the most significant corporate asset" and "investments in their knowledge and skills are necessary to build competitiveness". As a Toyota executive put it: "*To build cars we need to build people first. That is in essence the Toyota way*".

Considering the emphasis placed on employees in lean implementation, the results show very low levels of employee involvement. Further supporting this conclusion, some examples of lean projects were discussed in the previous chapter, where the lack of employee involvement was noted. Even though the survey showed many practices were in place under 'Human Resources Management' there is still potential to improve and extract more improvement by employee involvement.

In "The Toyota Way" model, respect for people is built on respect and teamwork. Respect is shown by asking an employee to contribute to solving a problem, and teamwork is used to help people develop and to maximise performance. The results showed a lack of team approach in problem solving and continuous improvement. There is also an inconsistency in how lean is implemented in different departments.

6.2.7 GUD has made productivity gains with the current implementation

Womack *et al*. (1990) described the huge differences in effort between companies using lean, compared to traditional manufacturing systems. The findings of their five-year study showed the lean factory using "one half the effort of the American luxury-car plants" and "greatly exceeds the quality level of all plants". Since then, numerous researchers have recorded the benefits achieved by the implementation of lean. These benefits are usually described in terms of the impact on the customer, impact on product costs, impact on quality and the impact on staff.

GUD has achieved savings that can be quantified in monetary value. The projects discussed in Chapter 5 show improvements that have been achieved by using various tools. Table 5.3 and Table 5.4 summarised some of the savings realised and in progress, by using the GPS methodology. These achievements can be attributed to the ability of the subject matter experts who were trained and have been deployed to do projects in different areas. The long-term sustainability of these initiatives is yet to be proven.

When discussing the progress and achievements of GPS, there was consensus that there has been an improvement in the culture of continuous improvement. This could be quantified by the number of improvement suggestions shown in Table 5.1.

6.3 Implications of this research

The principles of lean are primarily adapted from the Toyota Production System (TPS). Lean was one of the major enablers that helped Toyota become more cost-effective. As companies seek to become more competitive in the current economic climate, approaches like lean become very attractive. Researchers have proposed different implementation processes and some customisation for industry, but there are no clear-cut guidelines as to how lean should be implemented. This study focused on developing a better understanding of the application of lean principles as a toolbox and how these tools can be applied to improve productivity in a South African company.

Without understanding how to implement lean, companies will continue investing resources in lean manufacturing without achieving the desired results. This will eventually result in management losing faith in lean as an approach to performance enhancement. It will also result in frustration amongst workers as lean has a high dependency on employee involvement.

6.4 Limitations of the study

Limitations are variables that restrict the methodology and conclusions of the research. Some of the limitations that could influence the results are discussed below.

6.4.1 Sample size

In order to ensure the research achieved a confidence level of 95% and a margin of error of 5% required a sample size of 131. Questionnaires were administered until the target number was achieved. This meant repeated attempts to collect the data and the use of opportunistic timing, like making use of a power outage. In total 132 responses were received.

The sample was also restricted to the Durban site, even though the Pietermaritzburg site also participated in the GPS implementation. The Pietermaritzburg site was omitted because of accessibility for data gathering and additional production facilities have been added to the site in the last year.

6.4.2 Data collection methods

More detailed information could have been collected using qualitative means, but the limited time available restricted the data collection methods. A cross-sectional study was used, which gathers data at a given point in time. The data was gathered on different days, over weeks, and people may have responded to what was happening at that point in time, or in that week.

6.4.3 Administering the questionnaire

Most of the respondents in the research did not speak English as a first language. The questionnaire was therefore administered with the inclusion of people who could understand both Zulu and English to provide guidance where required.

Some of the initial questionnaires were not completed correctly as people did not grasp the scale. In order to improve the results, the first few questions were done with the entire team so that everyone understood what to do.

6.4.4 Data analysis issues

The data was entered manually into the Excel spreadsheet and this meant there could be human error in the data entry. The data was therefore double-checked to ensure there were no input errors. Mathematical formulae were used to ensure the numbers added up to 132 for all questions. These checks showed that there were no errors present.

The data was not analysed using statistical methods; instead, Excel was used to determine the response rate for individual questions and categories.

6.4.5 Lean tool bundles

Pettersen (2009) reviewed the lean tools frequently used to improve productivity and grouped these into nine interdependent bundles. These bundles were cross referenced with other researchers and used to structure the questionnaire.

It may be argued that this is not the most appropriate model, but it was clear and well-structured in comparison to some of the other research reviewed. The structure was adapted from the bundles but all the tool definitions used in the research were also taken from multiple sources.

6.4.6 Location of the study

This study was conducted at GUD in Prospecton, Durban, based on convenience and ease of access to the site. The results may not be applicable to other companies based on industry, business culture of company, structure of the company and size of the company differences.

6.5 Recommendations to solve the research problem

The following are recommendations to solve the research problems and are discussed below:

- Strategy and alignment
- Employee involvement and training to drive continuous improvement
- Management support
- Technology, tools and techniques
- Project structure
- Lean implementation costs.

6.5.1 Strategy and alignment

Researchers have found many organisations failing to establish a common strategy, vision and purpose that are fully communicated and deployed throughout the organisation. Strategy is aimed at aligning the entire organisation and guiding staff in how to focus their productivity improvement activities. A key part to this alignment is having a small set of appropriate, meaningful and engaging performance measures at each level of the organisation (Hines, 2012).

GUD has a vision, mission, and operating philosophies, available on the internal GUD intranet. This document is applicable only to the Durban manufacturing site, as it does not appear under the intranet pages of other manufacturing sites. This vision and mission are not deployed throughout the organisation, as people do not know it exists. Below are the vision, mission, and operating philosophies for Durban.

<u>The GUD Durban vision is:</u>

To Achieve Continuous Improvement and Growth through;

- *Commitment*
- *Integrity*
- *Service*

<u>The GUD Durban Mission is:</u>

To provide a World Class Manufacturing Infrastructure and Facility in Line with our Operating Philosophy

- ***Infrastructure** - Develop a quality and service orientated culture through flexible, high value added, cost effective Manufacturing, i.e. WORLD CLASS MANUFACTURING*
- ***Integrity** - Create a flexible, effective and efficient Manufacturing facility which is the pride of GUD, thus contributing to our competitive edge*

<u>The GUD Durban Operating Philosophy is:</u>

BELIEF	In Oneself and the goals of the Company.
ALIGNING	Our personal goals with those of the Company, in order to accelerate our achievements.
ENABLING	People to achieve these goals through:- - Opportunity - Training - Encouragement - Coaching - Empowerment
ACHIEVING	Our **INTERVENTIONS** through Continuous Improvement.
COMMITMENT	To a Forward Thinking Market Driven Organisation which is able to manage change to its advantage.
SERVICE SUPERIORITY	Will be our Goal and Competitive Edge.

This vision, mission, and operating philosophies can be aligned with the principles of lean manufacturing. Table 6.1 shows how the GUD Durban strategy can be linked to some of the guiding principles of lean manufacturing.

Table 6.1: GUD strategy linked with lean

Lean Strategy	**GUD Strategy**
Customer Focus	- A quality and service-orientated culture
	- Market-driven Organisation
	- Service Superiority will be our goal
Employee Involvement	- Enabling people to achieve these goals through:
	- Opportunity, Training, Encouragement
	- Coaching, Empowerment
Waste Removal	- High value-added, cost-effective
Continuous Improvement	Achieving interventions through Continuous Improvement

(Source: Compiled by Author)

The existing vision, mission, and operating philosophies need to be fully communicated and deployed throughout the organisation. This will align the entire organisation and guide staff in how to focus their productivity improvement activities. This vision can also be updated to include 'Lean Manufacturing' instead of 'World Class Manufacturing' so that all the initiatives are aligned under one approach.

The next step is to choose the performance measures that will be monitored at each level of the organisation. Currently, individuals are measured on a performance management system with no clear link between the different levels. This will complete the strategy and align the company goals to those of the employees.

6.5.2 Employee involvement and training to drive continuous productivity improvement

Lean implementation at GUD has been the result of a small group of specialists, who work in isolation, with little support from management, and little understanding from employees. Although there have been productivity improvements, the full benefits will only be realised if the employees see the benefits for them, and these employees are motivated to continuously improve. Some of the ways to achieve this are by ensuring the company policies, having rewards systems, and aligning employee progression and communications with the company strategy.

The lack of employee involvement is one of the main reasons for lean failures, so it is vital that the employees are engaged at the start. The first step is to start with training on the company strategy and secondly, lean training. Every employee should attend a training session where the top management presents the company strategy and launches the lean journey. The company strategy must be displayed throughout the factory.

The second step is to provide lean-specific training to all staff, so that everyone understands what lean is and how GUD plans to use lean to achieve the strategic objectives. This training can be done by the lean specialists within GUD or by external service providers. The lean specialist can also play a major role in coaching employees.

Once employees have been trained, it is important to get employees involved in project teams within their departments. The aim is to drive continuous productivity improvement and problem solving. As the team maturity improves, employees can participate in more complex problem-solving and cross-functional teams including other departments.

Recognition and rewards systems can be used to drive this process and thereby encourage employee participation. Employees with the most continuous improvement suggestions, most value add or best contribution to teamwork can be rewarded or recognised for their contribution. GUD can have a mini CFT conference where teams present individual projects to senior managers so that their contributions can be recognised. This forum can also be used to communicate with staff, share successes and transfer knowledge.

In order to ensure this effort is managed correctly, the strategic performance measures can be used to track overall progress. The current team meetings can be used to share performance information like customer complaints and defect rates. This information will also trigger more continuous improvement and problem-solving projects driving improvement in productivity.

6.5.3 Management support and training

Most researchers discuss management support in two parts. Firstly, top management support and secondly, middle management acceptance of the lean philosophy. Senior management will play a very important role in the implementation of any strategic project. Lean projects require commitment in terms of people and financial resources, and these decisions will be made at senior levels.

Senior managers need to do more than show support in the orchestrated meetings – there is a need to walk the shop floor and engage people to show the commitment to lean. The term "go-and-see" is often used in the lean literature to describe the need to see what is happening on the shop floor. Senior management need to continuously engage employees to listen to suggestions and re-enforce the commitment to the change. The performance information must also be communicated to all staff so that progress can be understood by all.

Holweg (2007) recorded that many lower level managers (superintendents and supervisors) found it difficult to implement a lean approach and the reason for this was the different management approaches required for lean and traditional mass production. This requires development and training of managers to be able to support employees in a lean environment. Some researchers have suggested that companies recruit personnel with lean experience in order to provide specialist knowledge and skills to support the change. This is not applicable at GUD, but succession planning should address the need for future leaders.

One way to ensure management is continuously involved in the implementation is by setting up a steering committee. Similar committees exist for quality at GUD. A core group of managers at different levels in the organisation must be selected to act as custodians of the productivity improvement process. This team will provide guidance and support in the planning and resource allocation, and track the progress. The steering committee will also provide teams with whatever support is required and resolve issues.

6.5.4 Technology, tools and techniques

Lean implementation should focus on three main areas, which are waste removal, levelling production and creating flow.

The majority of authors on lean focus on technologies, tools and techniques and many implementations start with the tools in complete isolation of the needs of the customer, the strategic need for change and the needs of their employees (Hines, 2012).

Some researchers argue for a philosophical approach to lean, whilst others suggest a more practical and project-based approach to lean (the toolbox approach). The recommendation for GUD is to use both approaches. The toolbox approach has already shown the productivity benefits that can be achieved using lean. These productivity benefits can be used to market the lean approach and get top management commitment to support the implementation.

Applying a lean philosophy is an organisation-wide change strategy and starts with the customer as a focus. This type of change has a much longer time horizon and lean tools utilised for this will be in the form of Womack and Jones's five key principles which capture the essence of the lean approach. This will also involve the use of more advanced lean tools like ‘value stream mapping’ and requires the engagement of lean specialists. Other departments like Technical and Finance not currently using lean will have to be included.

The toolbox approach can be used internally to drive culture change and focus productivity improvement by reducing waste and continuously improving operations. The success of this short-term approach will be determined by the knowledge and skills of the lean specialists and their ability to apply the lean tools.

6.5.5 Project structure

Currently, the Production Engineering and Quality Engineering teams are driving the productivity improvement processes. GUD has not changed structures whist implementing lean thus far. Going forward, there is a need to recruit a lean specialist to manage the project as there is a requirement for specialist knowledge on lean. The workload will also increase and the focus of individuals will be away from their daily operations.

The LEI also developed a lean transformation model to help companies achieve successful lean transformation. The roof is the value-driven purpose which is supported by the walls which are process improvement and capability development. The content of the house is made up of the management systems and the foundation is the basic thinking and mindset of the business. All of these elements come together to create a successful lean transformation. This a structure GUD can adopt to implement lean. The amount of training will increase in the short term and external service providers will have to be brought in.

Coetzee *et al*. (2016) listed the themes according to which lean implementation strategies are mapped. These are summarised in Table 6.2 below. These are essentially the steps that GUD can follow with the new lean implementation strategy.

Table 6.2: Themes of lean implementation strategies

Theme	**Activity**
1. Creating a vision	Develop Organisation Vision
2. Preparation	Establish Objectives and Implementation Plan
3. Value-stream mapping	Record the current state
4. Employee empowerment	Training, rewards systems, organisational structure
5. Implementation planning	Develop the future state map
6. Implementation	Standardise, Mistake Proof, Reduce Waste
7. CI.	Contiuously improve, measure, nurture

Adapted from Coetzee, R., van der Merwe, K. and van Dyk, L., 2016. Lean Implementation Strategies: How Are The Toyota Way Principles Addressed? *South African Journal of Industrial Engineering*, vol. 27, no. 3, pp. 79-91

6.5.6 Lean implementation costs

The savings already achieved and in progress at GUD demonstrate that lean is self-funding. In the short term there will be cost implications for training and developing employees. The value add in the long term will justify the expenditure.

6.6 Recommendations to for future studies

An important result of research is ideas that can be used for further research. The limitations as well as findings and recommendations of this study can be used to establish new research on lean implementation. The recommendations for future studies are discussed below.

6.6.1 Compare results of companies using different lean implementation methods

This study looked at GUD and the approach used at the GUD, Prospecton factory. Expand the study to include several companies and to identify the best approach to introduce lean by comparing the approach used by these companies and the outcomes achieved. The study could compare results using the same financial ratios used by MIT in the original study of the automotive industry.

A standard set of questionnaires like the one developed for this study can be used to collect data in different industries and regions to determine if there are regional and cultural implications.

6.6.2 Methodology versus knowledge of lean

Compare the outcomes of companies adopting the same implementation approach with and without subject matter experts. This study can also include companies that use external consultants. Some literature reviewed indicated that the experience and ability of lean experts can determine the outcomes rather than the methodology used.

6.6.3 The South African experience versus experience in developed countries

Most of the research reviewed was based on companies in developed countries. The workforce in these countries may be more educated and have a very different set of cultural values when compared to the South African workforce.

It would be beneficial to do a comparison between these cultural differences and their influence on lean implementation approach and outcomes. Such a study can help South African companies with determining how to reposition the culture of the company to support the lean implementation processes.

6.6.4 Factors influencing the type of lean implementation

Most companies have customised lean to suit their needs. Some researchers have found this to be problematic, others encourage customisation. Which of these companies have derived the most benefit from lean transformation? What are the factors that will determine the type of implementation and the amount of customisation? These questions could not be answered by this study and will assist companies embarking on lean transformation.

6.6.5 Administer another survey at GUD after implementing the recommendations

The current approach at GUD is described as “Toolbox Lean”. One of the recommendations is to continue with this approach in conjunction with applying the lean philosophy as an organisation-wide change strategy. Once lean transformation at GUD has progressed sufficiently, another study can be conducted at GUD to determine the impact of an organisation-wide strategy compared to “Toolbox Lean”.

6.7 Chapter summary

This research explored the effects of lean manufacturing implementation on productivity at GUD. The research investigated the link between strategy, tool selection, culture and the success of lean manufacturing implementation.

The literature reviewed showed different models for lean implementation ranging from strategic to operational. The Operational approach, also described as “Toolbox Lean”, focused on the application of tools. The strategic approach is more complex and focused on the lean philosophy and the goal was to create customer value.

The approach used at GUD was identified as “Toolbox Lean”. Although the data collected at GUD confirmed the presence of several of the tools identified in the literature review, areas with room for improvement were identified. One of the most concerning findings was the lack of employee involvement and low levels of training.

The study concludes that benefits can be realised even if a company uses lean as a toolbox for problem solving and continuous improvement. The tool selection will be determined by the approach the company uses, i.e. operational or strategic.

The application of a lean philosophy would result in lean implementation at a strategic level and introduce lean to other departments like Finance and Marketing. This complete organisational transformation will be driven by a change of culture and deliver better, and more sustainable results than “Toolbox Lean”.

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APPENDICES

Appendix 1 – Informed Consent Letter Zulu

UNIVERSITY OF KWAZULU-NATAL
GRADUATE SCHOOL OF BUSINESS AND LEADERSHIP

MBA Research Project

Researcher: Roshan Somaru (031 – 310 6703)
Supervisor: Dr Bibi Chummun (031 – 260 1615)
Research Office: Westville Campus (031– 260 7291) HSSREC

"Exploring the effects of lean manufacturing implementation on productivity at GUD"

IMVUME

Mina………………………………………………………………………(igama lakho eligcwele) ngiyaqinisekisa ukuthi ngiyakuqonda konke okuqukethwe kulencwadi kanye nohlobo lwalolucwaningo.

Ngiyaqonda ukuthi nginenkululeko yokuphuma kuloluphenyo uma ngifisa kanjalo.

ISIGNISHA YOMHLANGANYELI UMHLA WOSUKU

…………………………………………………………………………………………………

This page is to be retained by researcher

Appendix 2 – Informed Consent Letter English

UNIVERSITY OF KWAZULU-NATAL
GRADUATE SCHOOL OF BUSINESS AND LEADERSHIP

MBA Research Project

Researcher: Roshan Somaru (031 – 310 6703)
Supervisor: Dr Bibi Chummun (031 – 260 1615)
Research Office: Westville Campus (031– 260 7291) HSSREC

"Exploring the effects of lean manufacturing implementation on productivity at GUD"

CONSENT

I…………………………………………………………………………(full names of participant) hereby confirm that I understand the contents of this document and the nature of the research project, and I consent to participating in the research project.

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

SIGNATURE OF PARTICIPANT DATE

…………………………………………………………………………………………………

This page is to be retained by researcher

Appendix 3 – Letter of Introduction

UNIVERSITY OF KWAZULU-NATAL

GRADUATE SCHOOL OF BUSINESS & LEADERSHIP

MBA Research Project

Researcher: Roshan Somaru (031 – 310 6703)

Supervisor: Dr Bibi Chummun (031 – 260 1615)

Research Office: Westville Campus (031– 260 7291) HSSREC

"Exploring the effects of lean manufacturing implementation on productivity at GUD"

The purpose of this survey is to collect information from the factory regarding Lean Manufacturing. The information and ratings you provide us will go a long way in helping me identify what tools and practices are used in the factory.

The questionnaire should only take **8-10** minutes to complete. In this questionnaire, you are asked to indicate what is true for you, so there are no "right" or "wrong" answers to any question.

Work as rapidly as you can. If you wish to make a comment please write it directly on the questionnaire itself.

Your participation in this survey is voluntary. You may refuse to participate with no negative consequence. Your name is not required on the questionnaire, so confidentiality and anonymity will be maintained.

Indicate your answer with a tick.

Make sure not to skip any questions.

Thank you for participating.

Appendix 4 – Questionnaire

1. Gender

- Male
- Female

2. Age

- 18 – 20
- 20 – 29
- 30 – 39
- 40 – 49
- 50 – 59
- >60

3. Years of Service at GUD

- <1
- 1 – 3
- 4 – 6
- 7 – 9
- 10 – 12
- >12

4. Department

- Production
- Production / Quality Engineering
- Engineering Services
- Stores / Warehouse
- Technical

5. Role

- Operator
- Supervisor
- Superintendent
- Manager
- Production Support

6. How many hours of training have you received on Lean at GUD

- <1
- 1 – 5
- 6 – 10
- 11 – 15
- 16 – 20
- >20

7. Which one of the following statements best describes Lean at GUD

Lean is:

- Visual Management and Inono
- Elimination of Waste from all operations
- A way of thinking, a system and a philosophy
- Empowering people to continuously improve
- Value, Value Stream, Flow, Pull and Perfection

No	Question	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
8	I know what my daily production targets are.					
9	My daily production targets are always met.					
10	Peak periods are identified and resultant increased volume is taken into consideration when planning.					
11	My team improves the flow of work by eliminating delays.					
12	I understand the concept of 'value adding' activities.					
13	My department actively manages inventory to minimise the amount of stock in the internal component stores.					
14	I understand how my contribution helps GUD to achieve GUDs' overall goals.					
15	I am able to perform a variety of tasks in my department					
16	I am made aware of customer complaints that originate in my department					
17	My team discusses how to improve customer satisfaction.					
18	My team makes suggestions for improvement					
19	My team has had improvement suggestions implemented.					
20	In the past two years we have solved many problems through teamwork.					
21	I join teams from different departments to help solve problems.					
22	When problems are experienced we find and address the root cause.					
23	Our processes are designed to prevent errors.					
24	Errors are discovered at source and not later by downstream processes.					
25	Mistakes / Errors are often repeated, resulting in the same customer complaints.					
26	I understand what customers expect in terms of product quality.					
27	All customer complaints follow a specified flow.					

No	Question	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
28	My department has made improvements by changing processes.					
29	My department communicates with customers regularly.					
30	My department communicates with customers to understand customer needs.					
31	My workplace is well organised.					
32	All the work I do is guided by standard operating procedures.					
33	I receive training on documented procedures.					
34	On a daily basis team performance is discussed.					
35	My department uses visual management to track performance.					
36	All decisions made in my department are governed by company policies.					
37	My department changes layouts to improve material flow.					

End of the Questionnaire

Thank you for taking the time to complete the questionnaire.

Appendix 5 – Categories linked to questions and related tools

Category / Bundle	No.	Questions	Related Tools
Definition	7	Which one of the following statements best describes Lean	
Just in Time Practices	8	I know what my daily production targets are.	Continuous flow; Pull system (kanban); Production levelling (heijunka); Takted time
	9	My daily production targets are always met.	
	10	Peak periods are identified and resultant increased volume is taken into consideration when planning.	
	11	My team improves the flow of work by eliminating delays.	
Resource Reduciton	12	I understand the concept of 'value adding' activities.	Small lot size; Eliminating Waste, Setup reduction, Reduce Lead Time & Inventory
	13	My department actively manages inventory to minimise the amount of stock in the internal component stores.	
Human Resource Management	6	How many hours of training have you received on Lean	Cross Training Employees; Involvement of Employees; Emphasize Teamwork
	14	I understand how my contribution helps GUD to achieve GUDs' overall goals.	
	15	I am able to perform a variety of tasks in my department	
	16	I am made aware of customer complaints that originate in my department	
	17	My team discusses how to improve customer satisfaction.	
	18	My team makes suggestions for improvement	
	19	My team has had improvement suggestions implemented.	
Improvement Strategies	20	In the past two years we have solved many problems through teamwork.	Quality circles; Kaizen - To Continuously Improve; Root cause problem solving
	21	I join teams from different departments to help solve problems.	
	22	When problems are experienced we find and address the root cause.	
Defects Control	23	Our processes are designed to prevent errors.	Failure prevention (poka yoke); Autonomation (jidoka); 100% inspection; Stop production line on error detection (andon)
	24	Errors are discovered at source and not later by downstream processes.	
	25	Mistakes / Errors are often repeated, resulting in the same customer complaints.	
Supply Chain Management	26	I understand what customers expect in terms of product quality.	Value stream mapping; Process Flows; Supplier Involvement
	27	All customer complaints follow a specified flow.	
	28	My department has made improvements by changing processes.	
	29	My department communicates with customers regularly.	
	30	My department communicates with customers to understand customer needs.	
Standardisation	31	My workplace is well organised.	Housekeeping (5S), Standardized work, Visual Control; Visual management
	32	All the work I do is guided by standard operating procedures.	
	33	I receive training on documented procedures.	
	34	On a daily basis team performance is discussed.	
	35	My department uses visual management to track performance.	
Scientific Management	36	All decisions made in my department are governed by company policies.	Time & work studies; Policy; Layout adjustments; Labor Reduction
	37	My department changes layouts to improve material flow.	

Appendix 6 – Qualitative Interview Questionnaire

1. **Why GPS? What was the reason for putting the program together?**

2. **How did the team choose the tools / Design the program?**

3. **What was the plan of action after the CFT?**

4. **How were people trained on GPS after the CFT?**

5. **What were the outcomes expected by doing GPS?**

6. **What is your view of where we are now? Have we achieved the GPS objectives?**

7. **Has new managers / staff been trained on GPS?**

Appendix 7 – Research objectives linked to instruments

Objective	Description	Questionnaire	Interview
	Biographical Data	Q1 to Q5	None
Objective 1	To assess the existing manufacturing practices of GUD.	Q6; Q7; Q33	Q1 to Q7
Objective 2	To identify the lean manufacturing tools that impact on productivity improvement at GUD.	Q7 to Q37	Q2
Objective 3	To identify the lean manufacturing implementation processes that impact on productivity improvement at GUD.	Q6 to Q11; Q14 to Q22	Q1 & Q2
Objective 4	To determine how employee involvement in lean implementation enhances productivity at GUD.	Q6; Q11; Q14 to Q22; Q33;Q34	Q4 to Q7

Appendix 8 – Gatekeeper's Letter

G.U.D. Holdings

LEADERS IN AUTOMOTIVE PRODUCTS

11 June 2017

Mr R Somaru

P. O. Box 752

Scottburgh

4180

Dear Mr Somaru

RE: PERMISSION TO CONDUCT RESEARCH

Gatekeeper's permission is hereby granted for you to conduct research at GUD Filters towards your post graduate studies, provided Ethical clearance has been obtained from the University of KwaZulu-Natal.

We note that the title of your research project is:

"Exploring the effects of lean manufacturing implementation on productivity at GUD"

It is noted that this research will be conducted at GUD Filters, Prospecton Factory.

Data collected must be treated with due confidentiality and anonymity.

[redacted]

Evan Slack
General Manager Manufacturing
GUD Holdings (Pty) Ltd
Prospecton Site
+27(0)319103136
(C) 0824644851
email:slacke@gud.co.za

Appendix 9 – Certificate of editing

PROOF OF EDITING CERTIFICATE

TO WHOM IT MAY CONCERN

<u>Language editing</u>

I, Jeanne Enslin, acknowledge that I did the language editing of **Roshan Somaru's** dissertation submitted in partial fulfilment of the requirements for the degree of Master of Business Administration.

The title of the dissertation is:

Exploring the effects of lean manufacturing implementation on productivity at GUD.

If any significant text changes are made to the electronic document after I sent it to Roshan on 20 June 2018, I cannot be held responsible for any errors that are made. The quality of the final document, in terms of language, formatting and references, remains the student's responsibility.

Detailed feedback of all the language editing done has been provided to Roshan in writing and is evident in the dissertation in track changes with comments.

[redacted]

Language editor

082-6961224.

J H Enslin BA (US); STD (US); Hons Translation Studies (UNISA)

Appendix 10 – Ethical Clearance Document

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

16 August 2017

Mr Roshan Somaru (211522282)
Graduate School of Business & Leadership
Westville Campus

Dear Mr Somaru,

Protocol reference number: HSS/1192/017M
Project title: Exploring the effects of lean manufacturing implementation on productivity at GUD

Full Approval – Expedited Application

In response to your application received on 24 July 2017, the Humanities & Social Sciences Research Ethics Committee has considered the abovementioned application and FULL APPROVAL for the protocol has been granted.

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

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

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

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

Yours faithfully

[redacted]

....
Dr Shamila Naidoo (Deputy Chair)

/ms

Cc Supervisor: Dr Bibi Chummun
Cc Academic Leader Research: Dr Muhammad Hoque
Cc School Administrator: Ms Zarina Bullyraj

Humanities & Social Sciences Research Ethics Committee
Dr Shenuka Singh (Chair)
Westville Campus, Govan Mbeki Building
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Telephone: +27 (0) 31 [illegible]/4557 **Facsimile:** +27 (0) 31 260 4609 **Email:** [illegible] / [illegible] / [illegible]
Website: www.ukzn.ac.za

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