A LEAN SIX SIGMA FRAMEWORK TO ENHANCE THE COMPETITIVENESS IN SELECTED AUTOMOTIVE COMPONENT MANUFACTURING ORGANISATIONS

BY

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ABSTRACT

The South African automotive sector is often plagued with complex and competitive business challenges owing to globalisation, economic uncertainty and fluctuating market demands. These challenges prompt business leaders in South Africa to improve their operations and to enhance innovations in processes, products and services in a very reactive manner. Literature shows that one such initiative that can assist the automotive sector to compete with the rest of the world where productivity, quality and operational costs reduction are crucial for economic success is the adoption of the integrated Lean Six Sigma tool. The automotive sector, which purports to be at the forefront of best industry manufacturing practices in South Africa, is certainly lacking in this area.

The purpose of this thesis was to assess Lean and Six Sigma techniques as standalone systems, the integration of Lean and Six Sigma as a unified approach to continuous improvement and to develop a proposed Lean Six Sigma framework for the automotive component manufacturing organisations in KwaZulu-Natal (KZN), South Africa. Due to the nature and complexity of this project, it was decided to adopt the action-based research strategy and include both qualitative and quantitative techniques. Two hypotheses were formulated to guide the research. The study was confined to the greater Durban region in KZN, which formed the target population of forty two organisations within the Durban Automotive Cluster (DAC).

A survey questionnaire was designed in measurable format to gather practical information from the sample organisations on the status of their existing business improvement programs and quality practices. This information was necessary to critique the sample organisations for Lean and Six Sigma requirements and compare it to the literature in terms of the KZN context.

A pilot study was conducted with senior management at five automotive manufacturing organisations to determine if the participants encountered any problems in answering the questionnaire and if the methodology adopted would meet the objectives of this project. The results of the pilot study indicated high reliability scores which were sustainable for the main study. The survey questionnaire was reviewed by Lean and Six Sigma Experts, Academics and members of the DAC executive team to ensure the validity of the questionnaire to the KZN context. The logistics of the main study followed a similar format as the pilot study and the questionnaires were distributed within the DAC over a three month period. A census sample was used in the field study to collect primary data. A response rate of 75% was achieved.

The results of the empirical findings revealed that the sample organisations had a very low success rate of Lean and Six Sigma adoption as standalone systems. The sample organisations only practiced certain Lean and Six Sigma tools and techniques as they found it difficult to maintain the complete transition from theory to practice. The synergies that emerged from the study of Lean and Six Sigma that affect manufacturing performance suggested that they complemented and supported each other by tailoring the deficiencies to the given environment. This information was translated into practical considerations for constructing the proposed Lean Six Sigma framework from a KZN perspective. The conclusion of the main study was that if an organisation wants improvement to happen on an ongoing basis, it needs to recognise that there are significant interactions between their management system and the improvement technique. When the organisations understand the characteristics of the environment in which they operate, they will be able to configure appropriate follow up processes to sustain their management systems.

The study demonstrated that Lean Six Sigma integration repackages the stronger focus areas of Lean and Six Sigma to create its own unique approach on improving an organisation's performance. It is anticipated that organisations which implement the proposed Lean Six Sigma framework could contribute significantly to the growth of the South African economy in terms of increased productivity, improved international competition and job creation. The value of this research is that the proposed Lean Six Sigma framework affords the KZN automotive sector a unique opportunity to create its own brand of quality that compliments its management style and industry demands. Future research should focus on testing the applicability of the proposed Lean Six Sigma framework in a real case scenario to ensure that the critical outcomes are adequately ingrained to achieve perceived organisational performance. Lastly, it is recommended that a list of performance evaluators is developed and follow up procedures to monitor the progress of the Lean Six Sigma technique is implemented.

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DECLARATION BY CANDIDATE

I, Raveen Rathilall, declare that unless otherwise indicated, this thesis is my original work and that it has not been previously submitted for any degree at another Tertiary Institution.

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LIST OF ACRONYMS

BB	Black Belt
CEO	Chief Executive Officer
CTQ	Critical to Quality
DMAIC	Define, Measure, Analyse, Improve, Control
DAC	Durban Automotive Cluster
DTI	Department of Trade and Industry
DUT	Durban University of Technology
GB	Green Belt
GDP	Gross Domestic Profit
JIT	Just In Time
KZN	KwaZulu-Natal
MBB	Master Black Belt
MRP	Material Requisition Planning
NAACAM	National Association of Automotive Component and Allied Manufacturers
NAAMSA	National Association of Automobile Manufacturers South Africa

PDCA	Plan-Do-Check-Act Cycle
SMED	Single Minute Exchange of Dies
SPSS	Statistical Package for Social Sciences
TPS	Toyota Production System
TPM	Total Productive Maintenance
TQM	Total Quality Management
VOC	Voice of Customer
WIP	Work In Progress

GLOSSARY OF TERMS

Andon	A Japanese term that refers to the warning lights on an assembly line that light up when a defect occurs. When the lights go on, the assembly line is usually stopped until the problem is diagnosed and corrected.
Benchmarking	The process of finding an organisation that is superior in a particular area, studying what it does, and gathering ideas for improving one's own operation in that area.
Buffer Stock	A quantity of stock planned to be stored in inventory to protect against fluctuations in demand or supply.
Business Process re-engineering	A technique that focuses on the analysis and design of workflows and processes within an organisation.
Cell Manufacturing	A methodology that groups employees, machines and materials into a semi-circle or U-shape layout to produce a given product or product type.
Continuous Flow	Manufacturing where Work in Progress smoothly flows through production with minimal buffers between steps of the manufacturing process.
Continuous Improvement	A concept that seeks ongoing effort to improve products, services or processes. These efforts can seek "incremental" improvement over time or "breakthrough" improvement all at once.
Critical to Quality	Internal critical quality parameters that relate to the wants and needs of the customer.

Decentralised Responsibilities	The process of transferring and assigning decision-making authority to lower level employees in an organisation hierarchy.
Elimination of Waste	Any activity in production that does not add value to the finished product, such as excess inventory, unnecessary movements of employees, scrap, rework or transportation.
Employee Empowerment	An approach to teamwork that moves responsibility for decisions further down the organisational chart – to the level of the employee actually doing the job.
Five S (5S)	A methodology for organising, cleaning, developing and sustaining a productive work environment.
Gemba	A philosophy that reminds management to get out of their offices and spend time on the plant floor – the place where real action takes place.
Integrated Functions	A philosophy that enables employees to perform many different tasks in production.
Just-In-Time	It is a concept that controls inventory and material flow throughout the entire organisation. The philosophy involves providing the required part, in the correct quantity at the exact point in time.
Kanban	A Japanese word meaning “card” or “visible record” that refers to cards used to control the flow of production through an organisation. It signals the manufacture and supply of components.

Lead Time	The amount of time between the initiation of some process and its completion or the elapsed time between the receipt of a customer order and filling it.
Multifunctional Teams	A group of employees that are organised in a particular work area and are able to perform many different tasks. These teams are often organised along a cell based part of the product flow.
One-piece Flow	Refers to the concept of moving one work piece at a time between operations within a work cell.
Poke Yoke	Mistake-proofing methods aimed at designing failsafe systems that minimise human error.
Process	Any activity or group of activities that takes one or more inputs, transforms them, and provides one or more outputs for its customers. These outputs then serve as inputs for the next stage until a known goal or end result is achieved.
Pull Production	A philosophy that emphasises production planning to manufacture to order instead of manufacturing to stock. No one upstream should produce a part until the customer downstream requests for it.
Production Levelling	A form of production scheduling that purposely manufactures in smaller batches by sequencing (mixing) product variants within the same process.
Quality at the Source	A philosophy whereby defects are caught and corrected where they were created. It is the responsibility of every employee, work group, department, or supplier to inspect the work.

Quality Circles	Another name for problem-solving teams; small group of supervisors and employees who meet to identify, analyse, and solve process and quality problems.
Replenishment	Manufacturing products for the purpose of replacing stock that has been used up.
Root Cause Analysis	A problem solving methodology that focuses on resolving the underlying problem instead of applying quick fixes that only treat immediate symptoms of the problem.
Suggestion Programme	A voluntary system by which employees submit their ideas on process improvements. The objective of a suggestion programme is to promote employee involvement, creative thinking, and continuous improvement.
Theory of Constraints	A methodology used for identifying the most important limiting factor (constraint or bottleneck) that stands in the way of achieving a goal and then systematically improving that constraint until it is no longer the limiting factor.
Single Minute Exchange of Dies	A system for dramatically reducing the time it takes to complete equipment changeovers.
Value Engineering	A systematic and organised approach to provide the necessary functions in a project at the lowest cost. It promotes the substitution of materials and methods with less expensive alternatives, without sacrificing functionality.
Value Stream Mapping	A sophisticated flow chart that uses symbols and metrics to help understand the sequence of activities, visualise processes and track performance.

Visual Control	Visual indicators, displays and controls used throughout manufacturing plants to improve communication of information.
Voice of the Customer	It is a process used to capture the requirements/feedback from the customer and to provide them with the best in class service/product quality.
Work In Progress	Items, such as components or assemblies, required to produce a final product in manufacturing.
Zero Defects	A way of thinking and doing production tasks right the first time without manufacturing defects. This philosophy increases the organisations profits by eliminating the cost of failure and increasing revenues through increased customer satisfaction.

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CHAPTER 1

INTRODUCTION

1.1 CONTEXT OF THE PROJECT

This chapter provides a background to the study, while motivating the need for continued research on current approaches to enhance manufacturing systems and it introduces the research problem. It also defines the constructs that are contained within the title and the scope of the research. An outline of the aim and a theoretical backdrop to facilitate the attainment of the objectives are highlighted. The chapter concludes with a disposition over the structure of the thesis.

1.2 BACKGROUND OF THE STUDY

Globalisation and volatile market dynamics in the new millennium dictates intense competition. As a result, organisations have to deal with domestic competitors as well as with the best in class from an international context. This is due to the growing demand and expectation of customers while coping with increasing product complexity and limited resources (Antony and Desai, 2009:418; De Koning, Does and Bisgaard, 2008:2; Mathaisel, 2005:623; Antony, Kumar and Madu, 2005:862; Evans and Lindsay, 2005:2). To confront these challenges, organisations from every industry attempt to strategically enhance their operational excellence and management philosophies in order to sustain competitive advantage and to maintain a share in the market (Islam and Karim, 2011:44).

Although traditional manufacturing paradigms have been challenged over the years, Montgomery (2010:56) maintains that quality management has always been an integral part of virtually all products and services from a business standpoint. Historically, the quality evolution led to the proliferation of various business improvement techniques that are available today. Snee (2010:26) provides empirical evidence that improvement approaches may be short-lived in organisations; however, improving the bottom line never gets outdated.

There exists a number of business improvement techniques such as Total Quality Management, Lean Manufacturing, Value Engineering, Business Process Re-engineering, Total Preventive

Maintenance, Theory of Constraints and Six Sigma, to name a few (Pulakanam and Voges, 2010:154; Andersson, Eriksson and Tortenson, 2006:283; Shah, Chandrasekaran and Linderman, 2008:6680). Despite the tremendous growth of this variety, Naslund (2008:271) is of the opinion that since organisations often search for increased performance they find it difficult to identify the technique most suitable for what they are trying to accomplish in their quest to improve and sustain quality as well as improve productivity. He postulates that organisations often tend to switch from one technique to the next to reduce production cost, enhance productivity and to improve product quality.

Of the various techniques mentioned above, authors Starbird and Cavanagh (2011:20); Delgado, Ferreira and Branco (2010:513); Pulakanam and Voges (2010:154); De Koning et al. (2008:3); Shah et al. (2008:6679) and Arnheiter and Maleyeff (2005:5) contend that Lean and Six Sigma are the two current and most significant techniques that organisations attempt to implement in order to improve performance and compete globally. Su, Chiang and Chang (2006:2) claim that there has been an exponential growth in Lean and Six Sigma over the years. Success stories of Lean and Six Sigma implementation and subsequent improvements in organisations throughout the world have been showcased in both academic journals and trade publications (Pepper and Spedding, 2010:140-144; Shah et al., 2008:6679).

Although independent Lean and Six Sigma techniques have a common goal in improving the production and transactional processes of an organisation, it appears from literature that they are operationally and distinctly different. Each technique uses different approaches and principles to effect the improvement. For example, Six Sigma focuses on reducing process variation to improve quality while Lean, on the other hand, concentrates on eliminating waste to add value to the customer. Therefore, based on each technique's unique objective, De Koning et al. (2008:5-7), Su et al. (2006:2), Andersson et al. (2006:293) and Bendell (2006:259) are in agreement that Lean does not possess the tools to reduce variation while Six Sigma, in contrast, does not attempt to develop a link between quality and speed as does Lean. From this viewpoint, De Koning et al. (2008:15) state that synthesising Lean and Six Sigma into an integrated programme results in the combination of the best of both techniques. This combination, referred to as Lean Six Sigma, is supported by Snee (2010:9-11) as the latest generation improvement technique which integrates human and process elements into a programme that links and sequences improvement tools to an overall approach for innovation and business growth. Organisations which attempt to deploy Lean Six Sigma effectively can generate substantial savings annually as experienced in a wide range of leading industries that include chemical, automotive, finance, electronics, and health care (Zhang, Irfan, Khattak, Zhu and Hassan, 2012:602-604; Snee, 2010:12; Byrne, Lubowe and Blitz, 2007:5).

There are frameworks and models available for these two independent techniques; however, Thomas, Barton and Chuke-Okafor (2009:113), Shah et al. (2008:6680) and Bendell (2006:255-259) argue that there is limited literature on the integration of these techniques in relation to a specific framework or model. They further state that there are some attempts to integrate Lean and Six Sigma; however, it appears that one technique usually dominates the other and there is no logical explanation or theoretical compatibility for the integration of the two techniques. It can therefore be surmised that Lean or Six Sigma as standalone techniques have limitations that could possibly fall short of achieving overall operational excellence. For this reason, a rigorous alignment of these limitations and the development of a plan to build, improve and refine current theory on the dimensions of integrating Lean and Six Sigma is prompted.

In South Africa, the first democratic election in 1994 exposed the country to the global market. This democracy brought about growth in the country's economy, thereby increasing its competitiveness due to bold macroeconomic reforms. The Department of Trade and Industry (DTI) reported that South Africa's Gross Domestic Product (GDP) enjoyed steady and positive growth over the years. A significant contribution to South Africa's economy is attributed to the automotive sector which accounts for 6 percent of the country's GDP, employs approximately 300000 employees and is responsible for 12 percent of exports (http://www.southafrica.info/business/economy/sectors/automotive-overview.htm, 2011).

For the purpose of this study, the approach adopted is that globalisation is the predominant trend which influences the automotive sector in South Africa. The global economic crisis in 2008 had an adverse effect on the country's economy and affected the entire world economy, creating a state of recession. In this regard, the sector in the South African context was severely affected and felt the adverse impact of this recession which resulted in the government having to intervene with aid packages to save the industry from collapsing. Naude and Badenhorst-Weiss (2011:71) cite newsletters published by NAACAM (2009:1), reporting that there were approximately 20 percent of job losses in the South African automotive industry and a significant reduction in operations that stemmed from this recession as at March 2009.

As economies worldwide started their recoveries, the GDP in South Africa grew by 4.6 percent in the first quarter of 2010, due mainly to developing countries such as China, India, Brazil and African countries that stimulated trade and global commodity prices. However, South Africa's recovery was delayed due to a strong currency. The robustness of economic recovery in developing countries, led by China and India, suggests a need for the realignment of South Africa's export focus (DTI, 2011:13).

1.3 RESEARCH PROBLEM STATEMENT

Following the above information and the anecdotal evidence provided by Strauss and Du Toit (2010:302-303) who cite specific cases highlighted by IMD (2008:1), Global Competitive Index (2008:21) and Blanke (2007:20), reveal that various competitive challenges over the past few years have made the business environment contentious for South Africa to compete in the global market. Some of the challenges highlighted include poor infrastructure, weak macro-economy, low market efficiency, limited technology readiness and inappropriate business sophistication. Within the context of the South African automotive sector, Naude and Badenhorst-Weiss (2011:71) cite specific cases conducted by Venter (2008a) and Venter (2009b) where the main competitive challenge facing this industry is the lower percentage of local content utilised in the final product. Under these conditions, South Africa appears to be 20 percent more expensive than Western Europe and is 30-40 percent more expensive than China and India as an automotive manufacturing base. The main contributing factors that account for these challenges are the development and retention of a skilled workforce, insufficient knowledge of competitors and operational inefficiencies attributed to internal process problems (Naude and Badenhorst-Weiss, 2011:96; Strauss and Du Toit, 2010:304).

It could thus be argued that to compete with the rest of the world where productivity, quality and operational cost reduction are crucial for economic success as highlighted by the DTI's strategic objectives and outcomes for 2011-2014 (DTI, 2011:19), the South African automotive sector needs to be flexible to improve their business operations and enhance innovations in processes, products and services in a very reactive manner. This is posited by Islam and Karim (2011:43) who report that the manufacturing sector in any country is considered to be very important as it contributes significantly to the economy and creates enormous job opportunities. In a similar contribution, Naude and Badenhorst-Weiss (2011:96) document that the competitiveness and survival of the South African automotive sector has a direct impact on employment, the cost competitiveness of the industry and the economy.

With the purpose of growing the economy and given the strong competition that faces the South African automotive sector, ongoing research on latest business improvement techniques is necessary to assist the country to compete with the best in its class. Brand Pretorious, ex-President of NAAMSA, reported at the 2011 Car Conference that the automotive sector in South Africa is a centre of excellence and a strategic asset for the country and should therefore consider adopting a more robust business model to adapt to the changing environment (NAACAM, 2011:4). Accordingly, some of the existing challenges he proposed were that the industry should respond to include:

- Local and international economic recovery
- Emerging markets that dominate global production
- Increased regulation for local businesses
- Investment decisions based on cost, quality, flexibility and consistency of supply
- Industry to promote sustainability and transforming the business environment
- Taking advantage of opportunities provided by revolution in social media and the internet
- Meeting the expectations and fulfilling the needs of customers

From a theoretical and practical standpoint, the literature shows that one such initiative that can assist organisations in eradicating the competitive challenges highlighted above is the Lean Six Sigma tool which has been recently recognised as the most effective business improvement technique that provides the experience, concepts and methods to lead change and sustain global competitiveness (Snee, 2010:12; De Koning et al., 2008:7; Byrne et al., 2007:5; Bendell, 2006:259). The automotive sector, which purports to be at the forefront of best industry manufacturing practices in South Africa, is certainly lacking in this area. It appears that business leaders in South Africa adopt various improvement techniques through consultants, government funding, industry sectors or support from global sister organisations, the latest being either Lean or Six Sigma techniques which are adopted mainly as standalone and used in isolation. On closer examination of South African academic journals, relevant books, periodicals, newspaper articles, websites and consultation with various automotive manufacturers, there appears to be no indication to suggest that the automotive component manufacturing organisations in KZN, South Africa; are considering the integrated Lean Six Sigma technique as an optimum business improvement strategy. This is confirmed by Zhang et al. (2012:604) who identified that the integrated Lean Six Sigma technique has only been executed in the education sector in South Africa.

Although Lean Six Sigma has been receiving all the recent attention and popularity to provide outstanding business results, there is no logical framework that organisations can adopt, as suggested by Bendell (2006:259). Similarly, there appears to be no specific structure that integrates Lean and Six Sigma techniques into a framework that complements each other from a KZN perspective. In relation to the above, an investigation is needed for the automotive component manufacturing organisations in KZN to consider an approach that uses the best of both techniques to achieve better business results conceptually and operationally.

Therefore, the main research question for this study is: Will a Lean Six Sigma framework assist automotive component manufacturing organisations in KZN improve their overall business objectives to be more competitive?

In an attempt to answer the aforementioned broad research question, this thesis will address the following sub-questions to guide the research analysis:

- Would Lean achieve business excellence as a standalone improvement technique?
- Would Six Sigma achieve business excellence as a standalone improvement technique?
- Is there a relationship when integrating Lean and Six Sigma?
- What level of significance and benefit will a Lean Six Sigma framework provide for automotive component manufacturing organisations in KZN?

1.4 AIMS AND OBJECTIVES OF THE STUDY

The aim of this research is to determine how manufacturing organisations can improve their existing processes through the Lean Six Sigma technique. To achieve this, the research will develop a theoretical structure that integrates Lean and Six Sigma into a conceptual framework for automotive component manufacturing organisations in KZN.

Emanating from the problem statement in the previous section, the objectives will be to:

- Identify the advantages and disadvantages of using Lean as a standalone improvement technique;

- Identify the advantages and disadvantages of using Six Sigma as a standalone improvement technique;
- Establish the consequence of integrating Lean and Six Sigma to complement and reinforce each other;
- Design and determine the suitability of a Lean Six Sigma framework for automotive component manufacturing organisations in KZN.

1.5 HYPOTHESES

H_0 - A relationship does exist between the integration of Lean and Six Sigma to achieve overall business excellence.

H_1 - A relationship does not exist between the integration of Lean and Six Sigma to achieve overall business excellence.

1.6 SIGNIFICANCE OF THE STUDY

The lack of South African studies with a suitable framework for the implementation of the Lean Six Sigma tool prompted this investigation. A considerable alignment is needed to investigate the key constituent elements of integrating Lean and Six Sigma in terms of a KZN context. In order to determine the broad views of integrating Lean and Six Sigma as highlighted in recent literature, it is important to note that each technique needs to complement each other. Therefore, the main study will investigate organisational infrastructures, use of different tools and techniques, and management/employee involvement in improvement processes. The information is required to support each of these methods and to align them into a suitable framework that will guide the deployment of Lean Six Sigma from a KZN perspective. This idea can be aligned to the recommendations of Zu, Fredendall and Douglas (2008:645) and Shah et al. (2008:6680) which encourages researchers to explore the integration of Lean and Six Sigma into a unique approach to achieve operational excellence.

Businesses always seek new techniques to appease human and organisational problems. Naslund (2008:270-278) contends that businesses are more than likely to change from one technique to another, if the latter improvement technique is proved to be more promising. Since the purpose of any change method is to improve efficiency and effectiveness, he claims that the justification of older management techniques was deficient due to lack of performance improvement. In addition, Montgomery (2010:63) contends that properly constructed and validated simulation models are often good predictors of the performance of a new system. As a natural consequence, organisations can benefit immensely by using simulation models to study the performance of their own processes. Therefore, it can be deduced that integrating Lean and Six Sigma into a conceptual framework would provide a business improvement technique with minimum shortcomings.

This study attempts to identify possible shortcomings of existing continuous improvement techniques used in KZN automotive component manufacturers and provide critical success factors by using Lean Six Sigma to assist them in exceeding overall business excellence. It is anticipated that the result of the thesis will serve as a proposal detailing a customised implementation framework for KZN automotive component manufacturers to become more competitive and contribute to the country's economy.

1.7 RESEARCH DESIGN AND METHODOLOGY

The action-based research strategy was accompanied by an empirical study to fulfil the purpose of this project. In addition, qualitative and quantitative techniques were selected as the methodology to answer the research questions. Research data was obtained from primary and secondary sources. The initial step was to systematically investigate what unique performance measures Lean and Six Sigma offered the business world when adopted independently. This data was obtained through secondary sources selected from academic journals, relevant books, periodicals, newspaper articles and websites. Thereafter, the study examined the gaps, similarities and differences between Lean and Six Sigma as standalone systems in order to validate the rationale for combining them into an integrated business improvement tool. This part of the study was exploratory in nature and served as a vital means of seeking new insights to a problem and assessing phenomena in a new light. Cooper and Schindler (2006:143) advise that exploratory research is preferred when there is little existing knowledge available within the area of study and the objective is to find fundamental understandings and formulate hypothesis of the area under investigation. In addition, Sekaran (2006:120) claims that exploratory studies can also be conducted when some facts are evident for an investigation area but more information is required for developing a viable theoretical framework.

The next phase of the research involved the field study to collect primary data. This part of the study incorporated a self developed survey questionnaire in measurable format to gather practical information from the sample organisations on the status of their existing business improvement programs and quality practices. In order to ensure that the questionnaire achieved the expected outcome of this project, an extensive review of literature and survey type questionnaires developed by other researchers (Pulakanam and Voges, 2010: 158-161; Zu et al., 2008:645-648; Shah and Ward, 2007:803) in Lean and Six Sigma were consulted and adapted to inform the design instrument of this study.

The structure of the questionnaire was based on the following categories: organisations that practice the Lean technique, organisations that practice the Six Sigma technique, Lean Six Sigma critical success factors, and usage of different tools and techniques. These categories were clearly explained on the cover sheet of the questionnaire to avoid any misconception or ambiguity. The study adopted both open-ended and close-ended type questions in the questionnaire design. The closed-ended questions were incorporated in section D of the questionnaire and evaluated on a 5-point Likert Scale; ranging from “Do Not Agree At All” (1) to “Agree Fully” (5). These ratings represented the participant’s current status of Lean and Six Sigma requirements compared to the literature in terms of the KZN context.

The target participants included Directors, Managers, Six Sigma or Lean Specialists, Foremen or Supervisors, Engineers and Technicians. For the purpose of this study, a census sample was undertaken since it involved the choice of all participants that were in the best position to provide the information required. The study was confined to the greater Durban region in KZN, South Africa; which formed the population of forty two organisations within the DAC. The DAC is a well-established, proactive and ambitious public-private partnership between the eThekwini Municipality and the automotive industry in KZN that is focused on developing the competitiveness of this industry. The partnership was established in 2002 and enjoys the support of the major role players and stakeholders in the regional automotive industry. The DAC’s long term strategic objective is to double the industry size by 2020. The DAC assists member organisations to achieve World Class Manufacturing status through various initiatives (http://www.dbnautocluster.org.za, 2011).

A pilot study was conducted with senior management at five automotive manufacturing organisations to determine if the participants encountered any problems in answering the questionnaire and if the methodology adopted would meet the objectives of this project. The pilot test data acted as the catalyst to verify if the feedback received addressed the research questions appropriately (Cooper and Schindler 2006:76). Although the results of the pilot study indicated high reliability scores, there were some minor changes required in the questionnaire for sustainability of the main study. Therefore, based on the results of the pilot work and feedback received from the respondents, the researcher edited the survey questionnaire accordingly to ensure that it was comprehensive, understandable and valid for the main study. In addition, the questionnaire was reviewed by Lean and Six Sigma Experts, Academics and members of the DAC executive team to ensure the validity of the questionnaire to the KZN context. The logistics of the main study followed a similar format as the pilot study and the questionnaires were distributed within the DAC over a three month period. A response rate of 75% was achieved.

The Statistical Package for Social Sciences (SPSS) was used to process and analyse the data obtained from the questionnaires. Each quantitative question was analysed individually in terms of reliability, content and the frequency of responses. The methods employed for analysing the data collected included descriptive statistics such as frequencies, means and gap values and inferential statistics such as factor analysis, communalities and hypotheses testing.

1.8 DELIMITATIONS

The delimitations of this research will ensure that the boundaries of the study are made explicit. Therefore this study will be limited to the following constraints:

- Physical geographical location - Only selected automotive component manufacturing organisations who are members of the DAC will be included in this study. Automotive component manufacturers that are situated in other provinces in South Africa will not be considered for the study.
- Industry - The study focuses on the manufacturing sector and specifically the automotive industry within this sector.
- Sample - The research sample will include participants that are in management and senior level positions, specifically those involved in manufacturing and have knowledge of Lean and Six Sigma techniques. Frontline employees who are directly involved with the production processes will be excluded from this study.

- Lean Six Sigma – Due to the limited usage of the Lean Six Sigma technique in South Africa, international organisations will be used to compare and critique the results of this study. This constraint should not prevent the findings from being applied in terms of a KZN context.

1.9 LAYOUT OF THE THESIS

The thesis will be divided into five chapters. A brief description of the contents of each chapter is as follows:

Chapter 1 provides an overview of the global competitive challenges experienced in the automotive industry and introduces the integrated Lean Six Sigma technique and its objectives. This chapter also focuses on the background of the study, the rationale behind the research, the problem statement, the aims and objectives, and the scope of the study.

Chapter 2 presents a review of the literature on Lean, Six Sigma and Lean Six Sigma. It starts by investigating the unique performance measures Lean and Six Sigma offer the business world when adopted as standalone systems. Thereafter, the chapter investigates the rationale for combining Lean and Six Sigma into an integrated business improvement tool. The chapter then seeks to identify the common principles and tools required for the Lean Six Sigma technique. The challenges and critical success factors of Lean Six Sigma are also presented in this chapter.

Chapter 3 provides a comprehensive review of the research design and methodology adopted for the study. It provides a description of the research sample chosen for the empirical study. In addition, this chapter presents the selected data collection methods, the choice of statistical calculations that is used in this research, and the results of the pilot study. The main study is also introduced here.

Chapter 4 focuses on the findings and analysis. It discusses in detail the findings from the field work in order to compare and contrast the issues of Lean and Six Sigma as standalone techniques. The limitations of each technique will be highlighted and the justification for integrating the two techniques will be presented.

Chapter 5 will form the final chapter of this thesis and will provide discussions that lead to the conclusions and recommendations based on this study. The framework developed will be presented in this chapter. It will also identify the limitations of this study and outline future research directions.

1.10 SUMMARY OF THE CHAPTER

This chapter laid the foundation for the study by outlining the fierce competition that stems from globalisation and recession and the impact it has on the South African automotive industry. From the background, a list of continuous improvement techniques such as Total Quality Management, Lean Manufacturing, Value Engineering, Business Process Re-engineering, Total Preventive Maintenance, Theory of Constraints and Six Sigma were identified and evidence suggested that the integrated Lean Six Sigma framework is required to assist organisations to compete globally. The key challenges such as global economic recovery, dominating emerging markets, satisfying customer expectations and operational inefficiencies that affect the South African automotive sector from which the research questions emanate, have been identified and it has contextualised the research. The significance and benefits of the research highlighted the need to develop a Lean Six Sigma framework to assist automotive component manufacturing organisations in KZN to compete with the best in its class and to exceed overall business excellence. The chapter also introduced the reader to the structure of the designing instrument and methodology adopted to accomplish the project. The following chapter provides a discussion and review of related literature and reveals the arguments leading to the establishment and need for a structured framework for combining Lean and Six Sigma to a project.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

In keeping with the objective of this study to design a Lean Six Sigma framework for automotive component manufacturing organisations in KZN, it was decided to adopt a systematic approach and first investigate the performance improvement of organisations that adopt either Lean or Six Sigma as standalone techniques and then review the possibility of combining these two techniques as an integrated system. Therefore, this chapter will consist of four sections which will guide the investigation with existing available literature. The first two sections (2.2 and 2.3) of this chapter seek to provide background information and outline findings from the literature on case studies of Lean and Six Sigma that represent their key focus areas and what they have to offer to the business world.

Subsequently, section 3 (2.4) will investigate the various dimensions that encourage the possibility of linking Lean and Six Sigma to form the integrated Lean Six Sigma technique. It is intended that this will provide a broader understanding of Lean and Six Sigma’s related strengths and weaknesses as standalone systems and possibly highlight the areas of opportunities and improvements in addressing their weaknesses. In addition, section 3 (2.5) will present the benefits obtained from organisations which integrated Lean and Six Sigma into a business improvement technique. The uniqueness and strengths that surface from this integration will also be highlighted in this section.

Section 4 (2.6) highlights the principles recommended for the adoption of Lean Six Sigma. This section (2.7 and 2.8) will also explore some of the challenges and critical success factors that are suggested by organisations which have implemented the Lean Six Sigma technique as an integrated concept. The outline of the literature review process is demonstrated in Figure 1 to guide the understanding of the main outcomes desired in this chapter.

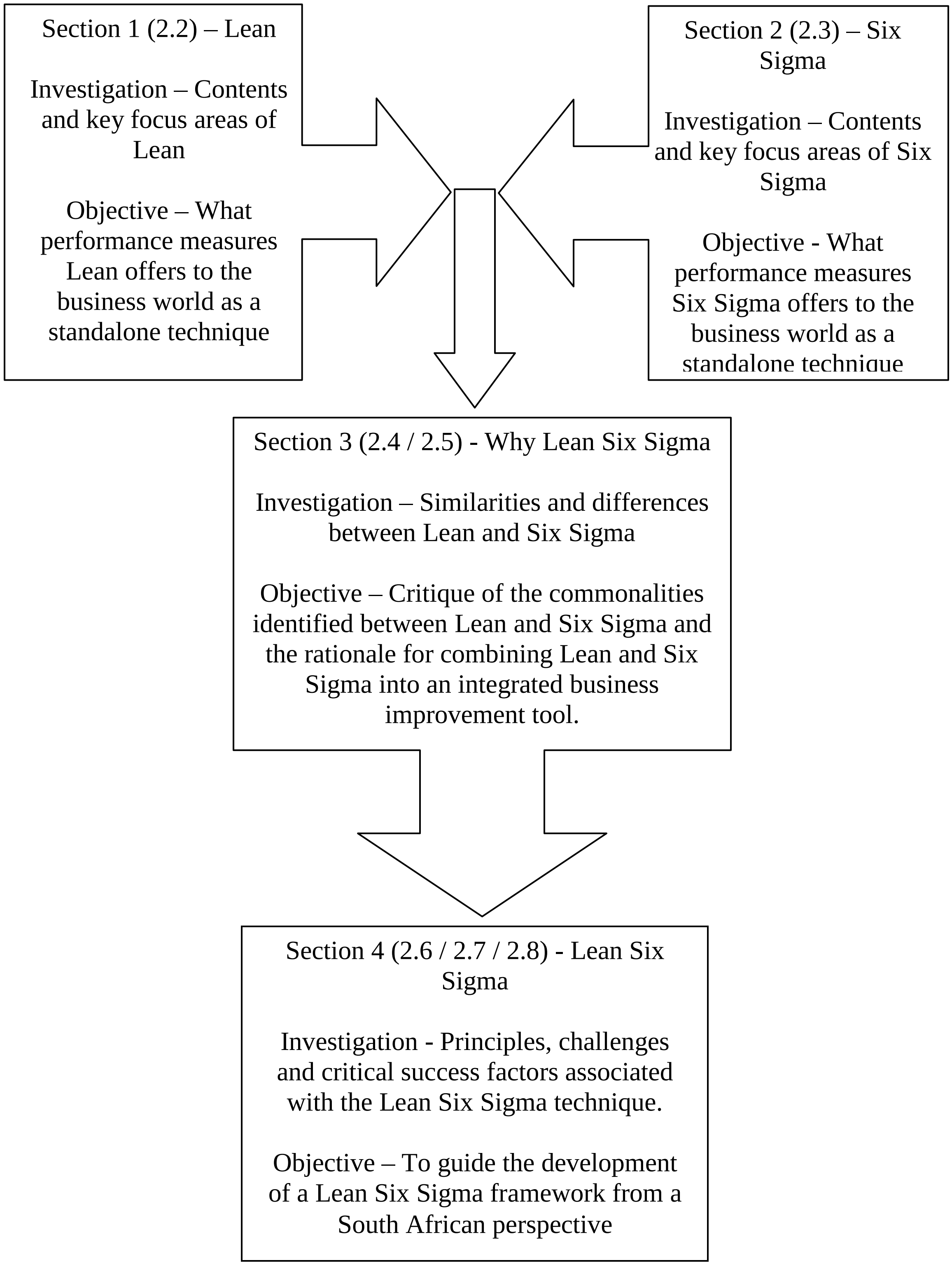


Figure 1 – Literature review process

2.2 THE LEAN TECHNIQUE

This section presents an overview of the Lean technique and identifies the main focus areas and improvement opportunities that it has to offer the business world.

The Toyota Production System (TPS) or Lean technique was introduced to the business world in 1990, through James Womack's book called "The machine that changed the world". This book provided an account of the history of automotive manufacturing combined with a study of Japanese, American, and European automotive assembly plants (Starbird and Cavanagh, 2011:19; Pepper and Spedding, 2010:138; Shah et al., 2008: 6679; Shah and Ward, 2007:787; Schonberger, 2007:406; Worley and Doolen, 2006:229). The result of this study was that the Japanese manufacturers in the automotive industry outperformed the American and Western European manufacturers drastically in terms of productivity, quality and competitiveness. Through this book and with the well known success of the TPS, the Lean technique became generally accepted in manufacturing in the Western world in the 1990's.

The ultimate goal behind the development of Lean, according to the various authors, was to eliminate waste in every possible process in an organisation (Salah, Rahim and Carretero, 2010:250; Montgomery, 2010:63; Chen, Li and Shady, 2010:1070; Nauhria, Wadhwa and Pandey, 2009:35; Shah et al., 2008:6681; Shah and Ward, 2007:791; Black and Revere, 2006:265; Bendell, 2006:255; Santos, Wysk and Torres, 2006:8). As such, Toyota identified seven major types of waste in the manufacturing environment that the Lean technique aims to reduce. These include overproduction of work in progress inventory, excess warehouse inventory, transportation of components, waiting for preceding processes, motion of unnecessary operations, inadequate processing steps, and defects requiring rework (Pepper and Spedding, 2010:139; Evans, 2008:268; Santos et al., 2006:7-8; Liker, 2004:28-29). Aside from these, Taj and Berro (2006:335) and Liker (2004:29) point out that emphasis was placed by organisations to actively engage and listen to the employees to sustain the Lean effort because it was perceived that the employees were in the best position to understand their processes. Therefore, unused employee creativity has been categorised as the eighth source of waste as it results in losing time, ideas, skills, improvement and learning opportunities.

The theory guiding the objective of the Lean technique is based on five principles which are as follows: defining value from a customer's perspective, identifying non-value added activities in the value stream, creating continuous flow in all processes, establishing pull systems and pursuing perfection (Thomas et al., 2009:114; Morgan and Brenig-Jones, 2009:15; Su et al., 2006:3; Andersson et al., 2006:288). These principles are used in conjunction with specific Lean tools and methods to maximise the value adding components in an organisation by using less human effort, space and time to produce high quality products as efficiently and economically as possible, while being highly responsive to customer demand.

It has been found that due to the advent of converging markets and business trends in the global arena, customers are only willing to pay for those activities that "add value" to a product or process (Chen et al., 2010:1070; Naslund, 2008:275; Bhuiyan and Baghel, 2005:763). In this regard, the Lean technique creates more value for customers by eliminating activities that do not "add value" to a product or service in an organisation. A benefit of reducing activities that cause waste in a manufacturing system would free resources such as humans who would then concentrate on activities that "add value" to the product or service (Starbird and Cavanagh, 2011:19; Karthi, Devadasam and Murugesh, 2011:310; Thomas et al., 2009:114; Pepper and Spedding, 2010:139). An encouraging outcome of "adding value" to processes is that they stimulate improvement opportunities in products and services that are critical to customer satisfaction and ensures that these processes have a positive contribution on the strategic goals of an organisation.

Hines, Holweg and Rich (2004:1006-1007) describe the existence of Lean at a strategic and operational level. The strategic level revolves around the customer while the techniques and tools apply to the operational level. Lean thinking at a strategic level and Lean production at an operational level are crucial to understand the entire Lean concept of providing customer value. To effectively achieve these outcomes, Hines, Francis and Found (2006:873) propose that it is essential to align the strategic goals of an organisation with the operational activities that create value in products and processes.

Fullerton and Wempe (2009:231) conclude that shop floor employee involvement is critical to the successful adoption of Lean which requires management support and communication (Worley and Doolen, 2006:243). Dahlgaard and Dahlgaard-Park (2006:279) argue that many Lean implementations focus primarily in training employees in tools and techniques rather than understanding the human factor and building the correct culture. Therefore, Fullerton and Wempe (2009:231) and Santos et al. (2006:4) advise that employee involvement at all levels in an organisation ensures success of the Lean technique. Since Lean implementation involves a total business process change, organisations cannot implement the Lean technique directly to their system by simply practicing the Lean tools and techniques (Motwani, 2003:340). It is a system that requires a total change of the employee's mindset in the organisation.

Shah and Ward (2007:791-792) are in agreement with Andersson et al. (2006:288) that Lean is a tightly coupled closed loop system which improves the performance of an organisation by investigating all aspects of the business and the impact it has on customers. They claim that Lean enables better housekeeping, provides a more organised workspace and creates knowledgeable and motivated employees. This leads to the conclusion that Lean strengths are pronounced in the continuous search for perfection by promoting all employees in an organisation to participate in continuous improvement. Perhaps this is the reason the Lean technique has acclaimed such high regard for process improvement. The Lean principles are necessary to guide and sustain process improvement in the form of removing waste and adding value to products and processes which validates its necessity in the context of this study. After providing some background information on the Lean technique and what it has to offer, the next section presents a review of the Six Sigma improvement technique.

2.3 THE SIX SIGMA TECHNIQUE

This section presents pertinent literature sources regarding the key focus areas of the Six Sigma technique. It outlines a brief background of Six Sigma, the contrasting viewpoints of the authors on the usefulness of the technique and the systematic process of improvement associated with Six Sigma.

A reliability engineer at Motorola, Bill Smith, pioneered the statistics and formulas of the Six Sigma technique in response to improve manufacturing yields in their products (Morgan and Brenig-Jones, 2009:15; Montgomery and Woodall, 2008:330; Raisinghani, Ette, Pierce, Canon and Daripaly, 2005:492). This technique was officially launched at Motorola in 1987 to sustain final product quality by focusing on obtaining significantly higher conformance levels (Arnheiter and Maleyeff, 2005:5-11; Bhuiyan and Baghel, 2005:763). The Six Sigma technique assisted Motorola in their quality drive at the time and culminated in them winning the prestigious 1988 Malcolm Baldrige National Quality Award (Snee, 2010:10; Andersson et al., 2006:286; Antony, 2006:234). However, the popularity and success of Six Sigma transformed and revolutionised the corporate world in the 1990’s through the work of Jack Welch at General Electric where he made Six Sigma a central focus of his business strategy (Corbette, 2011:121; Starbird and Cavanagh, 2011:20; Pulakanam and Voges, 2010: 149; Pepper and Spedding, 2010:142; Naslund, 2008:272; Evans, 2008:94; Black and Revere, 2006:260; Su et al., 2006:3; Bendell, 2006:256; Evans and Lindsay, 2005:9).

The aim of Six Sigma is to remove variation from processes and strive to manufacture defect-free products. It is considered a business strategy and a science that combines statistical and business methodologies which focus on continuous and breakthrough improvements to reduce manufacturing costs, improve customer satisfaction and to predictably produce world class products and services (Noone, Namasivayam and Tomlinson, 2010:275; Thomas et al., 2009:113-114; Antony and Desai, 2009:413; Banuelas, Tenant, Tuersley and Tang, 2006:514). The Six Sigma team members apply sophisticated root cause analysis techniques and obtain significantly more control and exploration into a problem as compared to any other quality improvement initiative (Schroeder, Linderman, Liedtke and Choo, 2008:549). The distinguishing feature is that continuous improvement is incremental whereas Six Sigma produces a dramatic improvement.

The acronym that is associated with Six Sigma is known as DMAIC and it stands for Define, Measure, Analyse, Improve and Control. This serves as the foundation and systematic five step problem solving methodology that is followed in Six Sigma to find causes of variation in system processes. The DMAIC cycle serves to define a process to improve, measure the baseline and target performance of the process, analyse the process data to determine the key process inputs that affect the outputs, improve the process to optimise the outputs, and, finally, to control the improved process for sustaining the improvement (Starbird and Cavanagh, 2011:168; Mehrjerdi, 2011:81; Foster, 2010:429; Noone et al., 2010:276; Nakhai and Neves, 2009:672; Przekop, 2006:57; Antony, 2006:239; Keller, 2005:49-50). To achieve these outcomes, Chen and Lyu (2009:445) and Chakrabarty and Tan (2007:196) report that Six Sigma prescribes the use of specific tools at each stage of the DMAIC cycle.

The Six Sigma toolbox comprises of the seven design tools, the seven statistical tools, the seven project tools, the seven Lean tools, the seven customer tools, the seven quality control tools and the seven management tools. Despite this variety, Pulakanam and Voges (2010: 157) advise that previous empirical studies indicate that the seven quality control tools are very popular and are commonly used in Six Sigma projects. Foster (2010:425-426) agrees with Pulakanam and Voges (2010: 157) that Six Sigma comprises ninety percent of the basic tools of quality and ten percent requires advanced training and analytical techniques. This implies that the main thrust of Six Sigma is to understand how the aforementioned concepts are packaged together and deployed within an organisation.

Operating at a Six Sigma level means that the organisation or process does not produce more than 3.4 defects per million opportunities (DPMO) (Karthi et al., 2011:310; Mehrjerdi, 2011:85; Montgomery, 2010:61; Pepper and Spedding, 2010:142; Noone et al., 2010:275; Kumar, Antony and Cho, 2009:670; Jenicke, Kumar and Holmes, 2008:453; Evans, 2008:93; Naslund, 2008:272; Black and Revere, 2006:264; Przekop, 2006:93; Antony, 2006:234). Barnes and Walker (2010:25) define an opportunity as a chance for non conformance or not meeting the required specifications. The statistical focus of Six Sigma reflects its basic philosophy which can be shared beneficially by customers, stakeholders, employees and suppliers. It is a technique that seeks to measure existing performance metrics and investigates how the desired and optimum performance level can be achieved (Nauhria et al., 2009:35).

In terms of management buy-in, Evans and Lindsay (2005:9) assert that Six Sigma is appealing to top executives because it focuses on measurable profit margins, a disciplined fact based approach to problem solving and rapid project completion. It should be noted that although the Six Sigma strategy was not common practice in previous quality improvement initiatives, it had gained the support from CEO's that TQM was generally unable to receive (Antony, 2004:303; Thevnin, 2004:196). From a practical perspective, Gupta (2005:21) acknowledges that Six Sigma has been recognised as an overall business improvement technique rather than just a measure of goodness or a methodology for defect reduction.

Another key strength of Six Sigma, according to Schroeder et al. (2008:546), is that it engages leaders in the improvement process on an ongoing basis. At the same time, the Six Sigma technique is not restricted to improvement efforts on the production floor only, but it also has effects in different facets of an organisation (Evans and Lindsay, 2005:18; Haikonen, Savolainen and Jarvinen, 2004:370). The literature indicates that Six Sigma motivates employees to innovate and improve their work environment, and ultimately their satisfaction on the job and personal self-esteem (Gupta, 2005:455; Evans and Lindsay, 2005:68).

The application of Six Sigma in a variety of industries as a quality management approach has brought many positive elements to the continuous improvement paradigm (Pepper and Spedding, 2010:144; Foster, 2010:424). Literature indicates that the Six Sigma technique has been practiced for over 20 years and it has demonstrated success in delivering value where business decisions are based on facts and accurate data (McCarty and Fisher, 2007:188; Gupta, 2005:455; Haikonen et al., 2004:370). Although Six Sigma started in the electronic industry, it is now deployed in all types and sizes of organisations and includes both the manufacturing and service sectors (Mehrjerdi, 2011:79; Nair, Malhotra and Ahire, 2011:529; Black and Revere, 2006:259; Antony, 2006:234; Thevnin, 2004:198; Antony, 2004:305). Since this study is confined to the automotive industry in KZN, South Africa; it is important to note that Ford was the first major automotive manufacturer to adopt the Six Sigma strategy (Arnheiter and Maleyeff, 2005:8).

There is consensus amongst the various authors that the ultimate goals of Six Sigma are to reduce variation and improve the profit margins of an organisation. The literature confirms that through the passage of time, Six Sigma has become a dominant factor in both manufacturing and service industries. Although De Koning et al. (2008:5) contend that Six Sigma builds on existing knowledge, Foster (2010:425-426) and Schroeder et al. (2008:537) differ in opinion as they assert that Six Sigma encompasses a unique application and deployment. After providing some background information and the key focus areas of Six Sigma, the following section of the literature review process discusses why Lean and Six Sigma should be combined into an integrated business improvement technique.

2.4 WHY LEAN SIX SIGMA

Although the previous two sections were inclined towards the positive association of Lean and Six Sigma as standalone improvement techniques, the section below will present a more integrated exploitation of the dimensions that encourage combining Lean and Six Sigma into a single unified initiative. Therefore, this section will compare and contrast the various dimensions that are associated with the objectives, strengths and weaknesses of Lean and Six Sigma to evaluate what relationship exists between the two and underpin the gaps which emerge from them as standalone techniques. Based on the relationship that is established, this section will provide a systematic approach to evaluate how each technique would possibly capitalise on the strengths of the other to improve its output when combined.

At the forefront as standalone business improvement techniques, it appears that Lean and Six Sigma have different performance measures but are popular in assisting organisations that strive for operational excellence to compete globally. On closer examination, Arnheiter and Maleyeff (2005:6) claim that organisations which have embraced either Lean or Six Sigma exclusively would eventually reach a point of diminishing returns and would have to investigate elsewhere for sources of competitive advantage. To this end, it resulted in Lean organisations examining the strengths of Six Sigma practices to gain a more competitive advantage and Six Sigma organisations exploring Lean tools to improve the efficiency in an organisation (Salah et al., 2010:251-252; Pepper and Spedding, 2010:147; Lee-Mortimer, 2006:13; Bhuiyan and Baghel, 2005:765).

The above explanation, according to Black and Revere (2006:265), provided an argument to the business world that if a process is operating at a Six Sigma level it did not necessarily mean that the process is Lean. They reported that the Lean advocates proposed that Six Sigma organisations needed the application of Lean tools to generate additional process improvement as a means of attaining superior business performance. A similar reasoning was applied to Lean organisations where the tools of Six Sigma were required to establish additional process improvement. Based on this rationale, Corbette (2011:118-121) claimed that the prominence of the Lean Six Sigma integration was undeniable and started to evolve for the purpose of capitalising on the strengths of both Lean and Six Sigma techniques by adopting the effective aspects and removing the limitations that had been identified over the years. He believed that since both techniques provided numerous successes in an organisation, the emerging trends in the business world indicated that by integrating the common dimensions of both techniques it would assist organisations to deliver strategic and operational objectives effectively. Table 1 compares and critiques the theories guiding Lean and Six Sigma based on the different dimensions highlighted in literature.

Concepts	Lean	Six Sigma	Critique
Origin	The quality evolution in Japan and Toyota	The quality evolution in Japan and Motorola	Similar
Primary effects	Remove waste	No defects	Similar
	Cycle time reduction	Uniform process output	Complimentary
Secondary effects	Cost reduction	Cost reduction	Similar
	Productivity improvement	Productivity improvement	Similar
	WIP reduction	Defect reduction	Different
	Shorten delivery time	Culture change	Different
	Space saving	Customer satisfaction	Different
	Less equipment needed	Market share growth	Different
	Driven for efficiency	Driven for excellence	Complimentary
Gaps	Causes congestion in the supply chain	Long project duration	Different
	Statistical or system analysis not valued	System interaction is not considered because processes are improved independently	Complimentary
	Process incapability and instability	Lack of specific speed tools	Complimentary
	There is no systematic problem solving approach	Six Sigma does not question existing methods of operation and if it is adding value, as long as it is does not produce variation	Complimentary
	Lean does not link quality and advanced mathematical tools to diagnose process improvement	No consideration for capital invested in inventory	Complimentary
Problem solving guidelines	Understanding customer value, value stream, analysis, flow, pull, perfection	Define, measure, analyse, improve (or design), control (or verify)	Different
	Improve speed and flow in processes	Reduce variation and improve processes	Complimentary
Tools	Analytical tools	Advanced statistical and mathematical tools	Different
Cultural settings	Typically driven by middle management	Typically driven by leadership	Confrontational
	Can be the culture, philosophy and thinking of an organisation - Requires personal commitment to challenge current processes	Can be the DNA, culture, philosophy, thinking, and standard of excellence of an organisation - Requires passionate and inspirational commitment to achieve perfection from CEO	Similar

Table 1 – Lean and Six Sigma comparison (Adapted from Andersson et al., 2006:290; Su et al., 2006:5; Gupta, 2005:19)

As highlighted in Table 1, it is evident that Lean and Six Sigma present similarities and differences, complementary and confrontational, depending on which aspect is looked at. Based on the various dimensions highlighted in Table 1, the subsequent sections will discuss the origins, primary effects, secondary effects, gaps, techniques, tools and cultural settings of each technique to investigate the effects of their compatibility when combined.

2.4.1 CRITIQUE BETWEEN THE ORIGINS

It can be seen in Table 1 that although Lean originated in the automotive industry and Six Sigma in the electronics industry, both techniques can be traced back to the quality evolution in Japan. It is also noted that Lean and Six Sigma are process-based improvement techniques as both were developed in the manufacturing environments. The advancement of these techniques over a period of time covering the later part of the 20th century paved the way into the business world when Western manufacturers had to study and modify their existing processes as they had to deal with the fierce competition posed by the Japanese manufacturers. From this starting point, the dimensions of Lean and Six Sigma have proven over the last twenty years that it is possible to achieve dramatic improvements in quality, productivity and profitability. Although Lean and Six Sigma are viewed as separate improvement techniques, it is evident that they share a similar objective in terms of improving business performance as highlighted by Laureani and Antony (2010:688) and De Koning et al. (2008:3). This point suggests that both techniques were established as a means of improving an organisation’s performance with the ultimate goal of sustaining a competitive advantage in the global context.

2.4.2 CRITIQUE BETWEEN THE PRIMARY EFFECTS

Within the context of Lean, the objective is to eliminate waste throughout a manufacturing system whereas Six Sigma, on the other hand, concentrates on reducing defects in a process. These, together, can be seen as complementary since some authors advise that comparing Lean and Six Sigma may be unproductive as both bodies of knowledge are needed to effectively solve problems encountered by an organisation (Snee, 2010:12; Bhuiyan and Baghel, 2005:765). A clear example is provided by Nakhai and Neves (2009:672) where Lean focuses on cost savings through the removal of non-value added activities and Six Sigma alternatively saves costs that occur from inferior quality. This is substantiated by Salah et al. (2010:250) who ascertain that eliminating waste shows a direct connection between Lean and Six Sigma since waste results from inefficient processes such as long cycle times and waiting times that Lean concentrates on or excess variation such as rework or scrap that Six Sigma investigates. Further description of these commonalities is represented in Figure 2.

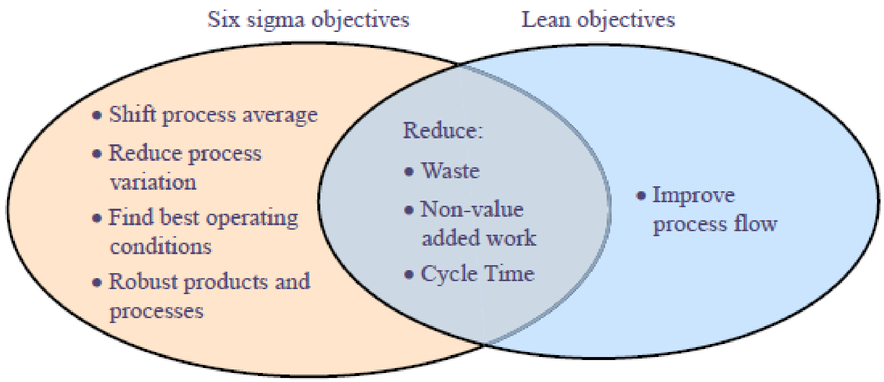


Figure 2 – Lean and Six Sigma improvement objectives (Adapted from Snee, 2010:14)

In the context of Figure 2, it is evident that Lean objectives are accomplished by improving the process flow or reducing the process complexity while Six Sigma objectives, on the other hand, are accomplished by shifting the process average or reducing the process variation. Thus, whilst both techniques have different focus areas, it is visible from Figure 2 that both techniques deal effectively with reducing waste; removing non-value added work and shortening the production cycle times. Although production cycle time reduction has been a key focus of Lean, it is also applicable to variation within the "value" adding transformation and process design efficiencies. One such example is that while Lean focuses on production cycle time reduction by removing waste such as distance travelled and non-value added activities, Six Sigma, on the other hand, reduces variation to produce a consistent process output which results in production cycle time reduction. Therefore, it can be surmised that Lean and Six Sigma share similar objectives of production cycle time reduction but have somewhat different directions towards the improvement.

From a historical perspective, Gupta (2005:16) widens the debate that the Six Sigma technique and the concept of production cycle time reduction (Lean tool) were simultaneously launched at Motorola. He states that the logic for this parallel implementation was to manufacture products correctly first (defect free) and then proceed to do it faster (efficiently). This scenario indicated that by completing production tasks faster (efficiently) before learning how to do it correctly (defect free) would result in creating waste sooner. Bhuiyan and Baghel (2005:765) conversely argue that waste should initially be removed from the process to make it faster (efficiency) and then reduction of variations should be sought out later which would be spotted more easily.

These salient points present the argument that since Lean requires doing a job efficiently through production cycle time reduction and Six Sigma concentrates on doing a job effectively through uniform process output, there is a need for combining these complimentary focus areas to strengthen the improvement activities in an organisation. Gupta (2005:3) compares Lean and Six Sigma to an analogy of two sides of a coin that are inseparable and must be practiced together. The consequence of this analogy is that when Lean is used in isolation it would not be able to maintain the necessary quality levels and when Six Sigma is practiced alone it would not be able to achieve maximum value of the improvement.

2.4.3 CRITIQUE BETWEEN THE SECONDARY EFFECTS

In comparing the secondary effects of Lean and Six Sigma, it is noted in Table 1 that both techniques produce similar, tangible results such as cost savings and productivity improvement in an organisation. These improvements suggest that both techniques are driven by customer requirements, have the ability to make significant financial impacts on the organisation, and can be used in both manufacturing and service environments. Consequently, the additional secondary effects of Lean such as Work In Progress (WIP) inventory reduction, shorten delivery time, space saving and less equipment are prerequisite factors needed to improve the efficiency in an organisation. On the other hand, the secondary effects of Six Sigma such as defect reduction, culture change, customer satisfaction and market share growth are prerequisite factors which improve the effectiveness of an organisation. Of particular interest is that both techniques will promote efficiency and excellence in an organisation when combined. The enthusiasm of maintaining efficiency and promoting excellence in an organisation is depicted in Figure 3.

<table>
<tr><td rowspan="2">Lean</td><td>Pull</td><td>Efficiency but sub-excellence</td><td>Excellence and efficiency</td></tr>
<tr><td>Push</td><td>Questionable conventional methods</td><td>Excellence but inefficiency</td></tr>
<tr><td colspan="2" rowspan="2"></td><td>Low</td><td>High</td></tr>
<tr><td colspan="2">Six Sigma</td></tr>
</table>

Figure 3 - Lean and Six Sigma relationship matrix (Adapted from Gupta, 2005:16)

By comparing the output of either Lean or Six Sigma as demonstrated in Figure 3, Gupta (2005:16) maintains that each technique has limited aspects of both Lean and Six Sigma improvements. For example, a Lean organisation may be efficient but not effective or a Six Sigma organisation may be excellent but not efficient. Therefore, an encouraging outcome of combining Lean and Six Sigma would drive efficiency and excellence together by achieving the synergy out of both techniques to produce the ultimate balance of improvement.

2.4.4 CRITIQUE BETWEEN THE GAPS

Although there are many success stories of performance improvements related to Lean, there are also inherent gaps in this technique that have been identified over the years. Nauhria et al. (2009:38) is in agreement with Andersson et al. (2006:289-290) that Lean cannot maintain customer demand if it is unstable and unpredictable. They posit that Lean reduces flexibility, causes congestion in the supply chain and is not applicable in all industries. A possible factor that contributes to this gap is provided by Arnheiter and Maleyeff (2005:10) where organisations find it difficult to maintain the concept of Just in Time (JIT) production through single piece flow of components between processes. This means that Lean is dependent upon a range of conditions being met to maintain particular market demands. In addition, Pepper and Spedding (2010:141) advise that organisations do not take into consideration the size and complexity of the product during the manufacturing process which cannot work in highly dynamic conditions.

In terms of process control, Bendell (2006:259) states that Lean is not designed to solve variation problems as it concentrates mainly on the naive removal of waste. In this respect, the authors concur that Lean does not have organisational infrastructures to manage the innovation efforts and it does not consider the use of statistical tools and the scientific approach to process and quality improvement (Nauhria et al., 2009:37; De Koning et al., 2008:5; Arnheiter and Maleyeff, 2005:13). For Su et al. (2006:6) Lean cannot bring a process under statistical control as it does not consider the variation that may be present in a measurement system. In addition, Lean does not link quality and advanced mathematical tools to diagnose and solve process problems. Furthermore, Morgan and Brenig-Jones (2009:36) argue that Lean does not have a systematic and controlled approach to maintain the improvement that is gained from the investigation. These arguments suggest that Lean works best with problems were the solutions are visibly evident to generate rapid improvements with minimal data collection (Hoerl and Gardner, 2010:32).

Contrarily, however, the weaknesses of the Six Sigma technique that prevail in literature indicate that the DMAIC cycle has been criticised for being complex and projects taking long to complete (Morgan and Brenig-Jones, 2009:36; Bendell, 2006:259). Central to this issue is the concern that additional defects may be produced if the identified problem is not resolved immediately which could result in excessive cost of poor quality. From a management perspective, it appears that Six Sigma does not incorporate a management decision-making process which bases every decision in relation to the impact it has on the customer. Andersson et al. (2006:292) are emphatic that Six Sigma concentrates mainly on the economical savings for the organisation and does not necessarily improve customer satisfaction as a successful TQM programme does.

The various authors contend that the selected hierarchy of process improvement specialists undergo intense training on intricate statistical and technical tools in order to work with Six Sigma improvement projects (Montgomery, 2010:62; Kumar et al., 2009:682; Montgomery and Woodall, 2008:332; Savolainen and Haikonen, 2007:9; Su et al., 2006:3; Andersson et al., 2006:287; Evans and Lindsay, 2005:15; Haikonen et al., 2004:372; Goh and Xie, 2004:237). This implies that the sophisticated tools of Six Sigma cannot be embraced by the average employee on the shop floor. For Pepper and Spedding (2010:145), the training and solutions that are put forward by Six Sigma can be prohibitively expensive for many organisations. Although Six Sigma improvement specialists undergo intense training, it has been noted in literature that creativity is needed to succeed in such an environment. This is confirmed by Hoerl and Gardner (2010:33) who accentuate that creativity is required to find effective solutions for complex problems that cannot be resolved with Six Sigma tools.

The major shortcoming of Six Sigma is that it is still an emerging concept to Lean (Pulakanam and Voges, 2010:155; Shah et al., 2008:6680) as it concentrates mainly on problem solving in a predefined process and does not consider the entire value chain or the overall organisational strategy and the impact that it may have throughout the organisation (De Koning et al., 2008:6; Arnheiter and Maleyeff, 2005:16-17). Drawing from these debates, it has been established that Six Sigma does not consider rapid solutions to simple problems as compared to a significant Lean initiative (Hoerl and Gardner, 2010:31). Furthermore, Six Sigma does not consider the interaction of all process elements to improve the effectiveness of its speed or reduce the amount of capital invested in inventory (Nauhria et al., 2009:38; Su et al., 2006:6). These concerns highlight that Six Sigma does not consider solutions for quick financial gains but instead focuses on a systematic approach to problem solving that is largely dependent on the quality of data required for conducting statistical analysis. The complexity of Six Sigma restricts its application for certain improvements and therefore preference is given to Lean for finding solutions must faster (Lee-Mortimer, 2006:13).

The arguments presented above confirm that both Lean and Six Sigma have weaknesses as standalone improvement techniques since each technique on its own does not incorporate all the performance measures that are required to lead an organisation to perfection. Although Lean has weaknesses pertaining to its objective of maintaining flow, the most significant gap is that it does not incorporate the tools to reduce variation. On the other hand, while Six Sigma has weaknesses pertaining to its objective of reducing variation, the most noticeable gap is that it does not attempt to develop a link between quality and speed as does Lean (Su et al., 2006:2; Andersson et al., 2006:290-294). In view of these concerns, it leads to the justification, as indicated in chapter one, that the weaknesses of Lean are identified as the strengths of Six Sigma. Therefore, it can be agreed that Six Sigma practices are required in a Lean organisation to achieve superior performance. Some of the additional advantages that Lean would capitalise from Six Sigma includes: use of statistical process control, stressing data-driven methodologies in all decision making, promoting applications that strive to minimise variation of quality characteristics, and implementation of a company-wide and highly structured education and training regimen (Thomas et al. 2009:114; Arnheiter and Maleyeff, 2005:17).

Similarly, the gaps that prevail in the Six Sigma technique reveal that it has limitations of Lean tools. For this reason, it can be emphasised that the strengths of Lean can address the weaknesses of Six Sigma, thereby creating a superior overall approach to organisational performance. Some of the additional improvement that Six Sigma would capitalise from Lean includes: consideration of the speed of the process, reviewing the impact that the improvement has throughout the entire system, incorporating an overriding philosophy that seeks to maximise the value added content of all operations, constantly evaluating if all incentive systems are in place to ensure that they result in global optimisation instead of local optimisation and incorporating a management decision-making process that bases every decision on its relative impact to the customer (Thomas et al. 2009:114; Arnheiter and Maleyeff, 2005:17-18). It can therefore be surmised that the challenges for Lean require the strengths of Six Sigma such as statistical analysis and the challenges for Six Sigma require the strengths of Lean such as tools that improves the efficiency of a process.

2.4.5 CRITIQUE BETWEEN THE PROBLEM SOLVING GUIDELINES

The five principles of Lean, according to Dahlgaard and Dahlgaard-Park (2006:268), were established as the foundation for reducing waste activities in an organisation and building Lean enterprises. They advise that the intent of these principles was to depart from a specifically functional approach and offer a more general way of understanding Lean and what it has to offer to the business world. One such example is provided by Andersson et al. (2006:288) who divulge that these principles are fundamentally driven to provide value to customers in both manufacturing and service sectors. On the other hand, Starbird and Cavanagh (2011:20) assert that the Six Sigma technique adopted the integration of quality, root-cause analysis and process improvement principles to incorporate a five step execution process that is commonly known as DMAIC. Although Table 1 at the start of this section depicts that each technique has a unique set of principles to guide the improvement process, Salah et al. (2010:265) demonstrate in Figure 4 the similarities that surface between the two techniques.

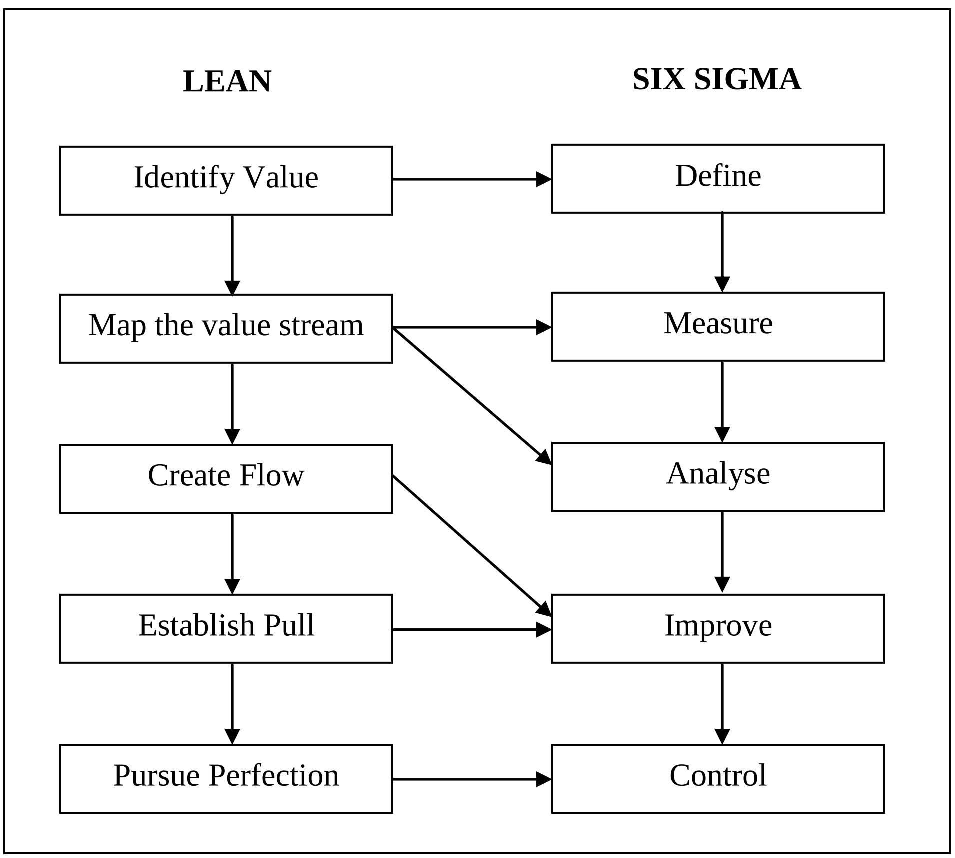


Figure 4 – Relationship between Lean and Six Sigma principles (Adapted from Salah et al., 2010:265)

As demonstrated in Figure 4 by principle 1, at the start of each technique it is noted that just as Lean focuses on understanding value from a customer's perspective so too does Six Sigma identify a problem and define it from a customer's perspective. This point reveals that both techniques consider the customers before embarking on any improvement.

The second principle of Lean is used to map the value stream by analysing and improving the non-value added activities that are identified in processes. Similarly, Six Sigma uses the measure and analyse phase, as highlighted in Figure 4 of the DMAIC cycle, to investigate key processes that causes variation in the value stream which can be regarded as non-value adding and waste. This point highlights that although each technique has different perspectives towards the investigation of a process, they share a common goal of improving the value stream either in the form of removing non-value added activities or reducing variation.

From Figure 4, the horizontal arrows for the third and forth principles of Lean point toward the improvement phase of the DMAIC cycle. This shows that the two Lean principles are similar to the improvement phase of the DMAIC cycle. For instance, since the third principle of Lean ensures that there are no unnecessary stoppages between processes and the forth principle of Lean synchronises production volumes to predefined customer demands, it can be interpreted that both principles depend on stable processes. Consequently, in the context of Six Sigma, the improvement phase of the DMAIC cycle focuses on finding alternative solutions to a problem so that it can produce stable processes.

The fifth principle of Lean plans for perfection by pursuing continuous improvement on an ongoing basis. On the other hand, Six Sigma similarly controls the improvement that has been implemented by continuously monitoring the processes.

Another argument presented by the various authors is that the DMAIC cycle appears to be a generalisation of Walter Shewart's Plan-Do-Check-Act (PDCA) cycle which implies that it can be used for other improvement opportunities in an organisation and does not have to be confined to the Six Sigma application (Foster, 2010:429; Naslund, 2008:272; Montgomery and Woodall, 2008:335; De Koning et al., 2008:6; Schroeder et al., 2008:542; Savolainen and Haikonen, 2007:10; Keller, 2005:50; Haikonen et al., 2004:371). In this regard, Montgomery (2010:64) claims that since the DMAIC cycle can be used in any problem solving situation, it can be just as effective for Lean as it is for Six Sigma; therefore, the integration of these concepts would provide an ideal system framework of continuous improvement.

Apart from the similarities discussed above, Salah et al. (2010:256) emphasise that both techniques encourage a complementary effect when combined as an integrated unit. They claim that during the improvement phase of the DMAIC cycle, additional improvement would surface through Lean principles by adjusting the process to make value flow and introducing the concept of pull. In addition, Schroeder et al. (2008:544) urge that by following each step of the DMAIC consistently, the best approach to solve problems is adopted. Therefore, for the purpose of this study, it is evident that the systematic improvement approach of the DMAIC cycle can be incorporated into any quality improvement system to produce a structured and controlled method to sustain improvement projects. It is worth noting that the DMAIC cycle would frame the overall strategy for the process of quality improvement in the context of this study.

2.4.6 CRITIQUE BETWEEN THE TOOLS

Reverting to Table 1, it shows that Lean consists of analytical tools while Six Sigma makes use of more advanced mathematical and statistical tools. Emiliani and Stec (2005:372) maintain that the intent of Lean tools and processes are to simplify work, improve quality, reduce lead time and enable employees to focus on performing only those activities that create value. They claim that the Lean tools must work together to accomplish the aforementioned objectives. For example, the JIT production system depends on the continuous flow of material and the pull production system. On the other hand, Andersson et al. (2006:287) cite cases by Magnusson, Kroslid and Bergman (2003) who highlight that Six Sigma contains design tools, statistical tools, project tools, customer tools, quality control tools and management tools in its problem solving methodology. From the wide list of tools, the literature indicates that statistical tools are more pronounced in Six Sigma problem-solving as there has been extensive growth in the use of statistical tools for quality improvement since the 1980’s. The objectives of statistical tools along with other problem solving tools serve as the technical foundation for quality control issues that underpin process improvement (Nair et al., 2011:529; Montgomery, 2010:59; Montgomery and Woodall, 2008:330). The statistical tools enable an organisation to initially understand fluctuations in a process and then identify the root cause of the problem (Naslund, 2008:271).

In the manufacturing environment, Lean offers simple tools without much mathematical refinement and is easy to apply in solving commonly encountered problems in the process while Six Sigma offers more sophisticated tools that require advanced knowledge on statistical and mathematical terms. Consequently, Lean tools are more intuitive and easier to apply by any employee in the manufacturing environment, whereas many Six Sigma tools require advanced training and the expertise of specialists. An example is presented by Evans (2008:269-270) where the concept of the 5S methodology of Lean is easier to grasp by all employees as compared to the statistical methods such as statistical process control of Six Sigma. Therefore, it cannot be denied that the Lean tools require less quantitative analysis than Six Sigma tools. This means that the Six Sigma tools can only be operated by employees who are specially trained in performing quantitative analysis.

Apart from the differences discussed above, Figure 5 depicts that Lean and Six Sigma also share common tools such as Brainstorming, Process Mapping, Standardisation and Mistake Proofing.

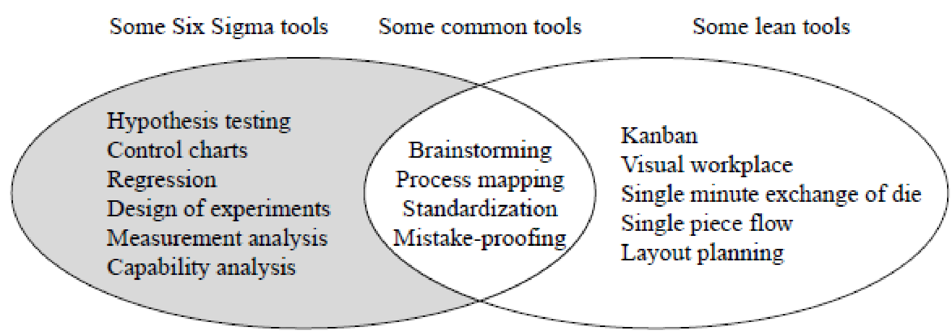


Figure 5 - Lean and Six Sigma common tools (Adapted from Salah et al. 2010:251)

From the list of tools represented in Figure 5, it can be concluded that they are not new to the field of process and quality management and have been brought together in a structured approach to form each technique. Although Snee (2010:14) contends that Lean and Six Sigma tools generally overlap each other in terms of problem solving, he believes that there are always improvements that may require specific Lean or Six Sigma tools. This leads naturally to the question of which tools should be selected to investigate a problem. Salah et al. (2010:251) advise that the Lean Six Sigma technique combines Lean and Six Sigma tools to ensure that the most appropriate tools are selected to investigate both the efficiency and effectiveness for a particular improvement area. There are a variety of tools that can be used for the integrated Lean

Six Sigma technique; however, all may not be required at once. The tool selected will depend on the nature of the problem. Each of these tools can be used in specific areas to produce critical outcomes in the improvement cycle. As a recommendation, Corbette (2011:129) highlights that the choice of selecting the appropriate improvement tool should be based on the complexity and focus area of the improvement. An encouraging outcome of combining Lean and Six Sigma tools is provided by Gupta (2005:424) who demonstrates in Table 2 how additional improvements can occur at each stage of the DMAIC cycle.

DMAIC Phase	**Key Six Sigma Tools**	**Key Lean Tools**	**Additional benefits of Integrating Lean and Six Sigma**
Define	Kano analysis, Pareto analysis, process mapping, SIPOC	Value stream mapping	Problem clarity and improved customer perspective
Measure	Measurement system analysis, Process capability assessment, Basic statistics, control chart, histogram, scatter diagram, check sheet	Cycle time, muda, yield	Sources of non-value added activity
Analyse	Root cause analysis, FMEA, Hypothesis, ANOVA, Correlation, Regression	Constraints, Takt time, cycle time	Better cause and effect relationship in process and product characteristics
Improve	Impact/Effort matrix, Advanced regression, component search, factorial designs, Force field analysis	VSM future state, continuous flow, kaizen, 5S	Efficient process flow with capable processes
Control	Control plans, control charts, process analysis, Metric scorecards	5S, TPM, visual controls, Kanban, Poke Yoke	Highly efficient and effective workplace, sustained customer focus

Table 2 - Benefits of integrating Six Sigma and Lean tools in the DMAIC cycle (Adapted from Gupta, 2005:426).

In relation to Table 2, the views of Pepper and Spedding (2010:151) are aligned with Gupta (2005:426) that if Lean is implemented without Six Sigma it may result in a limitation of tools to leverage the improvement to its full potential. Conversely, if Six Sigma does not incorporate the Lean tools it would provide a cache of tools for the improvement team to use, but there would be no strategy or structure to drive forward their application into a system. Antony (2006:241) supports the view that tools are practical methods and a means for assisting with investigation analysis. It is evident from Table 2 that when Lean and Six Sigma tools are used in conjunction with each other they would produce additional benefits at each stage of the DMAIC cycle.

2.4.7 CRITIQUE BETWEEN THE CULTURAL SETTINGS

Despite the wide knowledge and available resources, Liker (2004:34) points out that many books about Lean reinforce the misunderstanding that it is a collection of tools which lead to more efficient operations. He claims that organisations have embraced Lean tools but do not understand what makes them work together as a system. Dahlgaard and Dahlgaard-Park (2006:279) provide a similar argument where many Lean implementations focus primarily on training employees in the tools and techniques rather than understanding the human factor and building the correct culture. Therefore, an organisation requires significant cultural changes and a high degree of training and education of employees from upper management to the shop floor to operate Lean (Sim and Rogers, 2009:39; Bhasin and Burcher, 2006:58; Comm, 2005:71; Emiliani and Stec, 2005:384; Emiliani and Stec, 2004:630).

Conversely, McCarty and Fisher (2007:190) substantiate that invigorating leadership is needed to support the organisation and employees to operate with Six Sigma. They claim that a strong leadership structure is generally used to facilitate the inspiration and commitment of the employees. Pepper and Spedding (2010:144) claim that the employees must be able to experience the leadership passion for practicing Six Sigma and visualise the effects of the measurable results from successful improvement projects. They contend that management commitment and open communication play a pivotal role in Six Sigma. Management is expected to define, promote and launch the Six Sigma philosophy throughout the entire organisation and align it with their culture (Zu et al., 2008:644; Haikonen et al., 2004:377).

Apart from the above, the authors point out that Lean concentrates on management support and effective communication to work synergistically together while Six Sigma alternatively focuses on a strong leadership structure (McCarty and Fisher, 2007:190; Worley and Doolen, 2006:243; Gupta, 2005:22). These differences may be attributed to the management style of Lean being a bottom up approach in contrast to Six Sigma being a top down approach (Shah et al., 2008:6683; Montgomery and Woodall, 2008:333; Goh and Xie, 2004:237). Although a polarity exists between these two management styles, Montgomery and Woodall (2008:333) comment that the top down management style is significantly more effective compared to the bottom up approach because it appears to be unsupported by top management. The contrary argument reveals that both Lean and Six Sigma focus on the strategic and operational level of an organisation (Sim and Rogers, 2009:39; Jenicke et al., 2008:458; Zu et al., 2008:644; Bhasin and Burcher, 2006:58; Comm, 2005:71; Emiliani and Stec, 2005:384; Gupta, 2005:92; Haikonen et al., 2004:377; Emiliani and Stec, 2004:630; Hines et al., 2004:1006-1007).

The concept of employee involvement at all levels in an organisation is recommended in both techniques to sustain the improvement effort (Morgan and Brenig-Jones, 2009:11; Fullerton and Wempe, 2009:231; Santos et al., 2006:4). Starbird and Cavanagh (2011:96) acknowledge that the best way to drive performance improvement is to involve employees who do the actual work within the process. They recommend that by including employees in the process and performance improvement journey, it would result in better change acceptance from the entire organisation. It is evident that Lean requires a total business process change which includes the cultural aspects and employee's change of mindset to be able to adapt and sustain the system while Six Sigma requires a transformation within the entire organisation from top management commitment and leadership to cultural changes that will lead to cost effectiveness and excellent customer service. It can therefore be surmised that integrating Lean's cultural aspects with Six Sigma's commitment and involvement of top management through invigorating leadership would produce additional improvements at all levels within an organisation.

2.4.8 LEAN SIX SIGMA RATIONALE

The dimensions above highlighted to the business world that conventional processes had limited aspects of both Lean and Six Sigma improvements and proposed the need for integrating these techniques to create a unified improvement approach with minimum shortcomings. The logic was to capitalise on the strengths of both techniques and to help address the weaknesses of each technique as a standalone improvement technique. The linkage between Lean and Six Sigma are associated with each other in terms of their underlying philosophy, practices and techniques which have in the past been kept apart (Snee, 2010:14; Shah et al., 2008:6682-6683; Byrne et al., 2007:7). One such linkage and perhaps the most significant overlap are in quality management and business improvement. The justification of the Lean Six Sigma integration is represented in Figure 6 to highlight the summary and nature of improvements that would be gained by combining the two techniques.

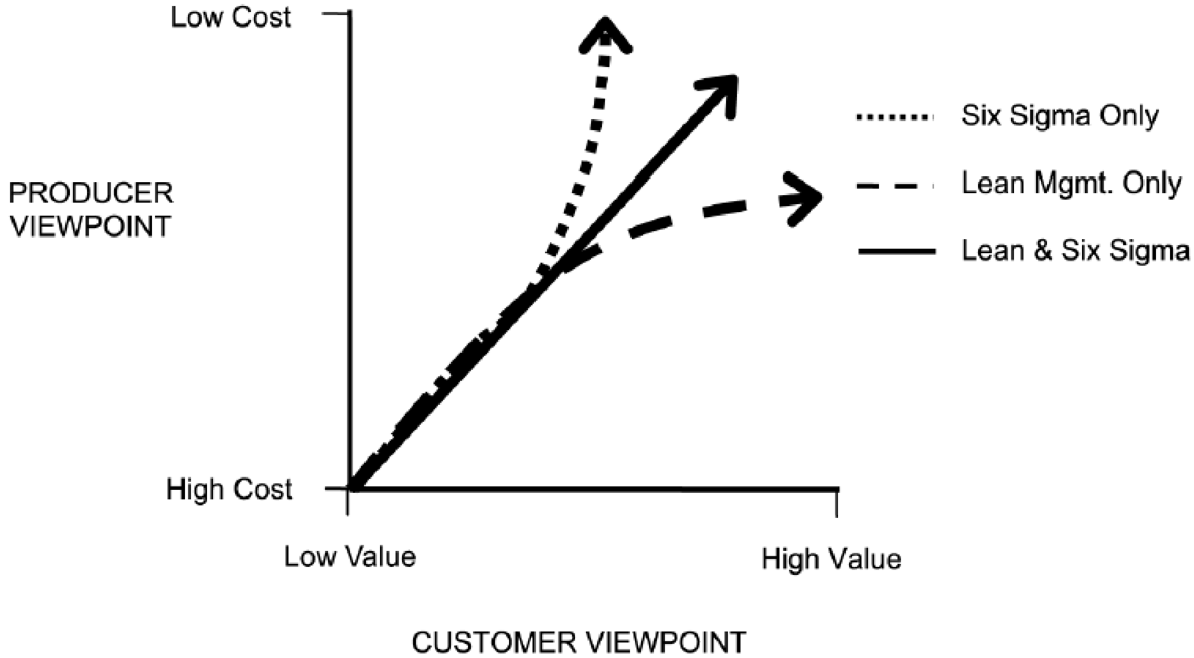


Figure 6 – Nature of Competitive advantage (Adapted from Arnheiter and Maleyeff, 2005:16)

The horizontal axis in Figure 6 represents Lean and the vertical axis represents Six Sigma. It is evident that when a state of equilibrium is reached, the Lean Six Sigma approach will not risk the possibility of the organisation becoming too Lean or concentrating too much on reducing variation. In order to capitalise on the strengths of both Lean and Six Sigma, Pepper and Spedding (2010:147) anticipate that the ultimate balance lies in creating sufficient value from the customers' perspective and reducing variation to acceptable levels. The core emphasis of this integration stems from the desire of aligning the cultural aspects of Lean with the data driven investigations of Six Sigma to sustain organisational change and process improvement. Therefore, Six Sigma allows the corporate leadership in the organisation to establish a vision and cultural change to achieve dramatic improvement while Lean provides visibility to the improvement (Gupta, 2005:18).

Further investigation reveals that Lean Six Sigma integrates the organisational infrastructure with Lean tools and Six Sigma capabilities to deal with problems relating to operational and strategic issues (De Koning et al., 2008:15). Several leading organisations that implemented operations strategies based on the elements of Lean and Six Sigma established disciplined working environments and significant process improvement. The desired outcome of merging the tools and principles of Lean and Six Sigma into an integrated business improvement approach is to increase customer satisfaction by providing high quality products and services at the required time and to improve the organisations overall performance in terms of efficiency and innovativeness (Gupta, Acharya and Patwardhan, 2012:198; Laureani and Antony, 2010:688; Nauhria et al., 2009:36; Byrne et al., 2007:5).

It can be surmised from these discussions that by combining the efficiency approach to problem solving through Lean with the innovative approach to problem solving through Six Sigma, enables an organisation to gain advantages from both types of improvement (Karthi et al., 2011:310; Hoerl and Gardner, 2010:31). In addition, the critique that was conducted on the various dimensions relating to Lean and Six Sigma suggests the need for the integration of these two techniques. The literature indicates that many researchers and practitioners have placed significant emphasis on the features of the Lean Six Sigma approach to achieve the synergy out of both techniques. On closer examination, Salah et al. (2010:250) and Bendell (2006:259) contend that Lean and Six Sigma are considered as the heart of business improvement approaches and it may result in a drawback or deficiency in the continuous improvement paradigm if either technique is implemented alone. Therefore, the concept of integrating Lean and Six Sigma was favoured over the years within organisations that chose for Lean and Six Sigma to work in unity rather than independently. This is supported and well documented by Snee (2010:10), De Koning et al. (2008:7) and Su et al. (2006:2) who claim that combining Lean and Six Sigma has attracted the attention of the business world and is the focus of current research in many academic and research institutions.

2.4.9 SUMMARY OF SECTION 2.2, 2.3 AND 2.4

This section dealt with the literature that was centered on establishing the link that exists between Lean and Six Sigma in order to provide an integrated business improvement tool. The key focus areas that prevailed from the various dimensions between Lean and Six Sigma were highlighted and then the Lean Six Sigma rationale built on the literature to lay the foundation of the research effort to justify the purpose of this integration. The resulting outcome from the analysis in this section revealed that Lean and Six Sigma have similar motives to remove waste and reduce costs in an organisation but differ in their approach to meet these objectives. The concepts presented show that while different vocabularies may be used, both techniques actually are very similar when it comes to creating the culture of continuous improvement (Pepper and Spedding, 2010:146; Arnheiter and Maleyeff, 2005:5-6). It can be interpreted that although each technique uses different performance measures to improve business outcomes, they both have effects that complement each other. The resulting outcome of this section revealed that Lean should focus on a more scientific approach to quality and Six Sigma should strive to adopt a wider systems approach by considering the effects of waste in the system. In addition, this section has demonstrated how each technique would gain significant advantages to improve their competitiveness and remove their weaknesses when combined as an integrated business improvement tool. The next section presents an overview of the benefits obtained by organisations which have adopted the Lean Six Sigma tool.

2.5 THE UNIQUENESS AND BENEFITS OF LEAN SIX SIGMA

This section presents the uniqueness of Lean Six Sigma and highlights the benefits obtained by organisations that implemented this technique.

In comparing Lean Six Sigma to techniques such as Total Quality Management, Value Engineering, Business Process Re-engineering, Total Preventive Maintenance and Theory of Constraints, Snee (2010:11) states that Lean Six Sigma is unique from those mentioned because it integrates the human and process aspects of improvement as summarised in Table 3. He claims that the aforementioned techniques do not consider all of the elements from Table 3 to improve an organisation's performance, which he believes is needed in today's dynamic environment as measured by quality, cost, delivery and customer satisfaction.

Human issues	**Process issues**
Bottom line focus	Process improvement
Management leadership	Analysis of variation
Sense of urgency	Disciplined approach
Customer focus	Quantitative measures
Project teams	Statistical thinking methods

Table 3 – Human and Process aspects of improvement (Adapted from Snee, 2010:11)

It can be concluded from Table 3 that Lean Six Sigma builds on knowledge, methods and tools that are derived from the human and process issues in an organisation to sustain business excellence. One way of connecting the human and process aspects of improvement is leadership as proposed by De Koning et al. (2008:7) and Bendell (2006:259). They claim that Lean Six Sigma provides the experience and concepts from a strategic perspective to lead change within an organisation. This is supported by Snee (2010:10) who posits that Lean Six Sigma provides the methods for improving processes and increasing value for customers by serving as a leadership development tool. He believes that the emphasis is on the leadership to increase employee involvement in process improvement teams and to move from a project completion focus to a continuous improvement culture. This promotes employees to actively participate in projects and results in an engaged and accountable team. For the leadership to be effective, Byrne et al. (2007:10) suggest that the organisation should be committed to perpetual innovation. They believe that innovation through leadership is often overlooked in many organisations. Therefore, Starbird and Cavanagh (2011:23) concur with De Koning et al. (2008:1) that the Lean Six Sigma technique would provide a unified framework to systematically develop innovations in processes and products.

To demonstrate the operational aspect of Lean Six Sigma, Salah et al. (2010:255) and Chen and Lyu (2009:453) claim that it provides a methodical approach of increasing overall business performance by improving the quality measures of products and processes and transforms an organisation from separate reactive operations into cross-functional process focused organisations. They believe that this is achieved by using the focus areas of Lean and Six Sigma which have different goals and combining them into one unified operation. What is of particular interest about these internally driven dimensions of flexibility is that it creates vision for innovation which permeates the organisation to strategically focus on the customer (Starbird and Cavanagh, 2011:97). Therefore, customer retention and customer satisfaction becomes a unique feature of the Lean Six Sigma technique. For Barnes and Walker (2010:25), Lean Six Sigma stifles creative processes and as such it can be effectively applied to the communication processes within an organisation to generate a steady flow of data and measurement. Under the mentioned circumstances, Corbette (2011:128) concurs in opinion and states that Lean Six Sigma engages the entire workforce to use the best improvement tools to target those aspects of the business that requires improvement. From the authors above, it can be gleaned that owing to the uniqueness of its nature Lean Six Sigma is made up of multiple components, each of which carry inherent benefits to improve the performance of an organisation.

Regarding the benefits of this technique, Byrne et al. (2007:5-9) are of the opinion that organisations generally view Lean Six Sigma as a simple process improvement and cost reduction technique. They claim that organisations are unaware of how this technique promotes innovation opportunities in the business. In addition, Lean Six Sigma focuses on improving overall business performance instead of operational improvements only. To this end, the various authors demonstrate in literature how Lean Six Sigma has presented benefits to the manufacturing and service sectors in the form of cost savings (Thomas et al., 2009:125-127), process and product innovations (Byrne et al., 2007:10), improved quality and productivity (Delgado et al., 2010:518; Chen and Lyu, 2009:448-451), active people involvement and fully trained resources (Corbette, 2011:128) and greater customer satisfaction and business excellence (Laureani and Antony, 2010:689; Nauhria et al., 2009:39; Byrne et al., 2007:5). It can be concluded from these authors that Lean Six Sigma provides the tools to lower manufacturing costs and become efficient to increase profitability and customer satisfaction. These are accomplished through procedural and cultural changes within an organisation that leads them to innovation and growth. After discussing the uniqueness and providing some benefits of this technique, the next section highlights the principles recommended for the adoption of the Lean Six Sigma technique.

2.6 PRINCIPLES RECOMMENDED FOR THE ADOPTION OF LEAN SIX SIGMA

The previous section presented the uniqueness and the benefits of integrating Lean and Six Sigma techniques. The section below will discuss literature illustrating the key principles which emerged for the adoption of an integrated Lean Six Sigma approach. The common principles which emerged are: focus on the customer, identify and understand operational activities, manage and improve the process flow, remove the non-value added steps and waste, manage by fact and reduce variation, involve and equip the people in the processes and undertake improvement in a systematic way (Morgan and Brenig-Jones, 2009:23-25).

The principles presented by Morgan and Brenig-Jones (2009:23-25), above, are also aligned with the work of Starbird and Cavanagh (2011:76), Snee (2010:22), De Koning et al. (2008:7) and Gupta (2005:117-18), who contend that each of these principles incorporates numerous improvement tools with which they can be supported for implementation within an organisation. They claim that the principle of managing and improving the process flow is directly linked with the concepts of JIT, Creating continuous flow between processes, Pull System, Standard processes and Standardised work, Quality at the source, 5S methodology, Cell manufacturing, Production Leveling, Total Productive Maintenance (TPM) and Single Minute Exchange of Dies (SMED). The principle of removing the non-value added steps and waste is associated with analysing the Value Stream and identifying the eight sources of waste in the manufacturing environment. The principle of involving and equipping the people in the processes includes the concept of continuous improvement. Lastly, the principle of undertaking improvement in a systematic way relates to the DMAIC cycle.

Overall, it can be interpreted that these principles have to work together with the tools mentioned above to support and enhance the positive effects of process improvement. Considering the types of tools mentioned and their potential and organisational wide applicability, it could even make a significant impact at all levels of the organisation.

Since the focus of this study is confined to developing a Lean Six Sigma framework for the KZN context and taking into consideration that there is no evidence of a similar study conducted in South Africa, it was decided to investigate all of the principles above. Therefore, the following sections will discuss the construct and rationale of each principle accompanied by tools that have been associated with their implementation to gain a broader understanding of the requirements for the Lean Six Sigma technique. The first principle, Focus on the Customer and the associated tools such as Voice of the Customer (VOC) and Critical to Quality (CTQ) will be presented in the next section.

2.6.1 FOCUS ON THE CUSTOMER

In the contemporary business context, Mehrjerdi (2011:80) is of the view that quality is generally defined by the customer, which he believes makes sense because it is the customer who ultimately receives the use of the outputs or benefits from a product or service. For Chakrabarty and Tan (2007:201-202) and McCarty and Fisher (2007:193), customer focus relates to the concept of creating Value as it has a direct impact on quality. They believe that it is important to determine how quality is viewed from a customer’s perspective because it is the customer who ultimately specifies Value in a product or service and not the organisation producing the product or service. From the aforementioned authors, it can be gleaned that association and communication with the customer and understanding the customers’ needs in a product or service is very important to provide what is required by the customer.

To understand how the concept of Value applies to industry, Carreira (2005:2) explains it as an activity that makes a product more complete than one which does not advance the product towards completion. Similarly, Starbird and Cavanagh (2011:170-171) claim that Value is created in a product or service when the process invests some type of effort in each activity that physically changes the product or service towards completion. It can be gathered from the authors above that it is vital for an organisation to understand what type of Value the customer places upon its products or services as a means of meeting their requirements. Furthermore, it would thus appear that an organisation's interaction and customer involvement are necessary to identify and implement the most suitable quality and improvements that are required in products and services.

Therefore, it was considered a point of departure to determine how to realise appropriate customer requirements. Delgado et al. (2010:518) contend that the VOC is a useful point to begin with as it usually describes what customers' require and their perceptions of how well the products or services meet their needs. They suggest that in an attempt to deliver exceptional customer experiences, CTQ characteristics should be specified by the customer. These characteristics should be aligned with the design and improvement efforts of the organisation to reflect what the customers expect from a product or service. Another view of understanding the CTQ characteristics is provided by Morgan and Brenig-Jones (2009:23-24) who suggest that the customers' CTQ characteristics provide the basis for the organisation to determine which process measures are critical, thereby assisting the organisation to understand what to provide and to evaluate how well it performs in achieving these critical requirements.

To add to another dimension of the CTQ characteristics, in recent years organisations have noticed that the customers' CTQ characteristics can consistently fluctuate and will continuously change due to dynamic market demands (Goh and Xie, 2004:238; Antony, 2004:304). In this regard, an organisation needs to have significant countermeasures in place to cope with erratic customer demands and improvements which are sought out by customers. One way of managing this dynamic environment is creativity as proposed by Hoerl and Gardner (2010:32-34). The creativity of the organisation may be required to cope with the existing market trends since the environment is dynamic and new problems and opportunities occur each day. They further recommend that the CTQ characteristics should not only be viewed from a customers' perspective but also from an internal business perspective so that it can reflect a measurable format of customer requirements and the impact of adhering to them has on the organisation.
In relation to the above, it is evident that customers are continuously involved with decisions that affect their products. Additionally, organisations which improve their performance in meeting

the customers' CTQ characteristics are likely to win and retain further business and increase their market share.

Snee (2010:20) is convinced that the prime objective of Lean Six Sigma is to focus on improving processes and operational activities in a way that improves the outputs which are of critical interest to the customers and the organisation. Against this background, it should be stressed that customers are the most important people for an organisation and maintaining their satisfaction, loyalty and retention are essential for an organisation to be successful. Therefore, the next section will discuss the principle of identifying and understanding operational activities.

2.6.2 IDENTIFY AND UNDERSTAND OPERATIONAL ACTIVITIES

This principle relates to the depth of knowledge and understanding the management team within an organisation has on all the processes that are involved in manufacturing a product or delivering a service to the customer. Although the literature indicates that the Value stream tool is commonly used to describe all steps involved in manufacturing a product or delivering a service, Morgan and Brenig-Jones (2009:67) report that by visiting the workplace and spending time observing how operational activities are performed creates a better understanding of the process. Furthermore, the Japanese refer to this concept as going to "Gemba" which means that the management team or improvement specialists make their way to the production floor on a daily basis to review the effectiveness of operational activities in the process. Salah et al. (2010:270) acknowledge that by continuously visiting the workplace and applying the Value stream tool to all areas of the business assists the management team and improvement specialists in identifying improvement projects on an ongoing basis.

To add to another dimension of identifying and understanding operational activities, Emiliani and Stec (2005:373) and Liker (2004:152) claim that visual control is commonly used as a type of communication device in the production environment to indicate at a glance what should be done and whether the operational activities are deviating from the standard. They believe that visual control aims to assist employees in observing immediately how well they are performing, where items belong, what the standard procedure is for performing a task, the status of work in progress and many other types of information that are critical to the flow of work activities. From an application perspective, Santos et al. (2006:172) are in agreement with Keller (2005:263) that visual control in the production environment broadens the employees' awareness of identifying possible process problems much faster so that they can take the necessary corrective actions.

Another view of understanding the concept of visual control is provided by Schonberger (2007:406) who is of the opinion that an organisation which facilitates visual control creates an environment that makes quality visible to all employees. One of the popular visual control techniques is called “Andon” which uses alarm lights to warn the employees if an activity is deviating from the standard and signals management that help is needed to solve the problem (Santos et al., 2006:173; Liker, 2004:130). Morgan and Brenig-Jones (2009:159) provide an example where “Andon” can be used as a light signal to highlight when more stock is required at a process. In support of the above viewpoints, Starbird and Cavanagh (2011:130) claim that visual control has become an integral part of Lean Six Sigma as it highlights the workflow status and problems that surface during production to the entire team in the work area.

The discussions above lead to the conclusion that potential improvement ideas can be gathered from going to “Gemba” and applying visual control techniques to all processes in an organisation. From a more practical approach, Emiliani and Stec (2004:636) suggest that a leader who questions all processes and supports continuous improvement opportunities motivates the employees to do so as well. Thus, this principle serves as a measure to improve the performance of the targeted work area and to create a positive human resource outcome not only to identify better ways of working, but to also rewrite and redefine previously set standardised work. Furthermore, it can be viewed as a method that strengthens employee involvement (management and shop floor) in the improvement process and aids the change process through proactive training. This type of setting would create an atmosphere of trust, approachability, improvement in the business knowledge and enhancement of the employees’ morale. After reviewing the principle of identifying and understanding operational activities, the following section of the literature review will discuss the principle of managing, improving and smoothing the process flow.

2.6.3 MANAGE, IMPROVE AND SMOOTH THE FLOW OF ACTIVITIES BETWEEN PROCESSES

In order for an organisation to continuously identify and eliminate non-value added activities from its processes, it has to manage, improve and smooth the process flow on an ongoing basis.

Morgan and Brenig-Jones (2009:24) state that this principle stimulates the use of different thinking mechanisms and tools within an organisation for enhanced resource utilisation and process optimisation. They claim that an organisation uses the various Lean tools that are associated with this principle to challenge the employees to constantly work towards maintaining a smooth flow of activities between processes. These tools consist of JIT, Creating Continuous Flow between Processes, Pull System, Standard Processes and Standardised Work, Quality at the Source, 5S Methodology, Cell Manufacturing, Production Leveling, TPM and SMED. An overview of each tool will be discussed in the following sub-sections as it reflects a critical disposition towards the important constructs that are necessary to maintain a smooth flow of activities between processes.

2.6.3.1 JUST IN TIME

The JIT production system enables an organisation to manufacture and deliver products in smaller quantities and at reduced lead times to meet specific customer requirements (Morgan and Brenig-Jones, 2009:12; Liker, 2004:23). These are accomplished by providing the required parts, in the correct quantity and at the exact point in time. It can be seen as a "hand-to-mouth" operation with production and delivery quantities approaching one single unit. This means that only one component will move in sequence to the next operation when required. Under these conditions, the various authors contend that the material flow between equipment and activities should be kept to a minimum to maintain a single piece flow between processes. They believe that this can be achieved through the reduction in lot sizes, buffer sizes and order lead time (Schroeder, 2007:411; Chase, Jacobs and Aquilano, 2006:474; Santos et al., 2006:21; Heizer and Render, 2004:605).

To add to another aspect of the JIT production system, Dahlgaard and Dahlgaard-Park (2006:265) stipulate that JIT is not an easy task to implement in an organisation that continuously produces defects. They believe that a small defective part can stop the entire production system. In this context, Schroeder (2007:396) claims that JIT can be closely related to Zero defects since the parts that arrive at each process needs to be fault free to achieve the sequential flow. One way of managing the JIT production system is smaller lot sizes as proposed by Naslund (2008:275) and De Koning et al. (2008:5) where smaller lot sizes make it easier to identify quality related defects immediately at each process. They recommend that smaller buffers require each process operator to perform a quick quality check before moving their output to the next person in the proceeding process. If a defect is detected, the operator is expected to stop the process immediately and rectify the problem. Through this method, the JIT production system can assist an organisation in two ways: firstly, by identifying defects as they occur instead of manufacturing products in large quantities and secondly, by not storing products unnecessarily.

It can be gleaned from the review above that the JIT production system operates with minimum inventory throughout the organisation. One possible downfall of minimum inventory is that the organisation may not have sufficient stock available if there is a disruption in supplies from a supplier. This could force production to cease at a very short notice or there could be no finished goods available to meet unexpected customer orders. On the other hand, the ideal situation in JIT production, according to Rawabdeh (2005:801), is for all materials to be actively in use as elements of work are in progress and never at rest collecting unnecessary storage costs. He believes that the JIT production system reduces the costs associated with capital invested in inventory and storage space. Therefore, it can be concluded that the JIT production system is essential for modern supply chain management as it can assist an organisation in maintaining sufficient control of stock between processes; and, as indicated above, it should be managed closely to prevent any disruptions throughout the supply chain. Forming part of the JIT production system is the concept of creating continuous flow between processes which will be discussed next.

2.6.3.2 CREATING CONTINUOUS FLOW BETWEEN PROCESSES

According to Keller (2005:263), the concept of creating continuous flow between processes in a manufacturing environment refers to the speed at which a process can manufacture products while still being able to provide flexibility in product variety and improved responsiveness to customer demands. He believes that by improving the flow of products through each process, an organisation would be able to respond efficiently to new orders or changes in delivery schedules that are requested by the customer. Closely related to this idea, Bhasin and Burcher (2006:57) and Mathaisel (2005:629) state that flow is considered a key ingredient to the different forms of waste because if there is a stoppage of product flow for any reason in the supply chain, waste can occur as downtime among others. From this point of view, they claim that an organisation can maintain a continuous flow of products between processes when material replenishment is initiated by consumption through a preceding process.

Another requirement for managing the flow in production processes is provided by Domingo, Alvarez, Pena and Calvo (2007:141) who recommend that organisations investigate the following aspects: the linkage between processes, the production conditions and the characteristics of each process. They advise that by doing so, these aspects provide the baseline for maintaining a continuous flow of products between processes. Sharing a similar view, Starbird and Cavanagh (2011:172) believe that each process should have sufficient capacity to meet customer demands and have production control systems in place to manage the linkage between processes. They claim that creating a continuous flow of products between processes would reduce the cycle time of the value stream and improve throughput capacity. From the above, it can be interpreted that the outcome of creating continuous flow between processes in an organisation is to link the employees with the processes so that the material and information moves efficiently together. It is evident that flow is a significant part of the JIT production system as it focuses on moving products from one process to the next based on the employee's interaction with them. Accompanying Flow is the concept of the Pull System which is needed to work in conjunction with the JIT production system.

2.6.3.3 PULL SYSTEM

From a historical perspective, the various authors concur that the Pull System was created to prevent an organisation from manufacturing products in advance and storing unnecessarily (De Koning et al., 2008:5; Schonberger, 2007:412; Andersson et al., 2006:288; Santos et al., 2006:174; Mathaisel, 2005:630; Arnheiter and Maleyeff, 2005:9). These authors maintain that the Pull System is closely related to Flow and serves as a notification for a process to manufacture a product or deliver a service based upon a specific customer request. One such example is provided by Morgan and Brenig-Jones (2009:13) who state that in a production environment, a downstream process would highlight when it needs the product from a preceding process and it will also stipulate the quantity. They claim that the Pull System ensures that no work is performed on a product unless it is required by the downstream customer.

Another consideration for this concept is from Shah and Ward (2007:799) who state that the Pull System works in conjunction with JIT production through the use of Kanban cards which serves as a signal to start or stop production. The Kanban card is the actual signaling device used to trigger production personnel to manufacture the correct quantity of material as it is required for each process in a sequential manner. In order for an organisation to synchronise the production levels to predefined customer demands, Nauhria et al. (2009:35) highlight that the Pull System corresponds with the actual usage or consumption of material by the customer. Therefore, it can be interpreted from the authors above that the concept of Pull controls the movement of material between processes as well as the production of new materials to replenish those sent downstream to the next process. It is evident that the Pull System can assist an organisation to maintain sufficient inventory levels in the form of warehouse stock that is required for production, Work In Progress stock that is required for the next process, and finished goods stock that is ready for delivery to the customers. It can be concluded that an organisation would have better control of inventory and visualise material shortages early in the supply chain process by using the concept of the Pull System.

2.6.3.4 STANDARD PROCESSES AND STANDARDISED WORK

Krichbaum (2008:2) states that standardised work methods are used in an organisation to provide a detailed description to the employees on how to perform a series of predefined steps when operating a process. He claims that the standardised work represents the current best practise in the organisation for the optimisation of a process and consistency of output. Similarly, Morgan and Brenig-Jones (2009:12) contend that standardised work methods seeks to reduce variation in the way an employee performs a task that has been prescribed for a specific process. They advise that standardised work methods enable an organisation to gain more flexibility and uniformity for each process and assist the employees to consistently produce the same level of quality. This means that the sequence of job elements are arranged in such a way that it can be repeated by another employee and it provides ease for training new employees to perform a task.

The above reasoning is extended in a similar fashion to standard processes that are required for continuous improvement activities in an organisation (Krichbaum, 2008:2). In this context, Anand, Ward, Tatikonda and Schilling (2009:454) suggest that processes need to be standardised, stabilised and provide valid baselines for analysis before any improvement can be made. They claim that if a process is not standardised and continuously shifts from one parameter to another, then any improvement implemented will result in additional variation surfacing to the process. The standard processes provide organisations with a stable basis from which to measure continuous improvement. From the viewpoints of the above authors, it can be concluded that standardised work methods prevent employees from performing tasks according to their own style which could impact the quality of the product. The employees will generate the same results consistently as long as they follow the procedures prescribed by the organisation which will maximise the performance of each process. Perhaps it can be suggested that standardising individual tasks and operating procedures can reduce unnecessary movement and energy of the employees.

2.6.3.5 QUALITY AT THE SOURCE

Solving quality-related problems at the source is a concept, according to Liker (2004:130), which places the responsibility on the employees to identify, restore and eliminate defects during each operation. Evans and Lindsay (2005:177) refer to this concept as “on line” inspection which ensures that components passed from one process to the next conforms to specification. From an operational perspective, Santos et al. (2006:78) claim that the implication of “on line” inspection could result in employees making subjective judgments and unintentionally accepting items that should be rejected. Therefore, as a preparatory step to “on line” inspection Olivella, Cuatrecasas and Gavilan (2008:800-802) suggest that the organisation train employees with a great body of knowledge on how to solve quality-related problems at the source since they witness production events first hand. In support of these views, Lee and Peccei (2008:5) articulate that the traditional organisational perspective requires specialists to solve quality-related problems; however, this has changed over the years in best practice organisations where employees on the shop floor have taken the responsibility for quality improvement.

To add to another dimension of solving quality problems at the source, several authors share a similar opinion that “Poke Yoke” devices are a form of source inspection that are commonly used to identify and eliminate defects in production (Morgan and Brenig-Jones, 2009:148; Evans, 2008:312-315; Schonberger, 2007:406; Liker, 2004:133). “Poke Yoke” is a Japanese term that means mistake proofing. These are creative devices that are designed to prevent defects from moving to the next process and make it nearly impossible for an operator to perform an error (Chase et al., 2006:333). The dynamic capability of “Poke-Yoke” is focused on predicting that a defect is about to occur and to provide a warning, or detecting that a defect has surfaced and stopping the process. The advantage of this concept is that it presents opportunities for the employees’ to pursue more creative and value adding activities in production rather than focusing on looking for defects. As a recommendation, Santos et al. (2006:73) suggest that “Poke-Yoke” devices should be used in conjunction with “on line” inspection in order for the two techniques to be effective.

In relation to the above, it can be interpreted that it is practical for employees to inspect their own work as it would assist them in identifying defects as they occur and prevent them from moving the defective product to the next process. However, under these circumstances, the employees need to be trained on the quality standards that are required for each process. It is also important to empower the employees to correct the defects that occur as a means of assuring quality. It can thus be established that by correcting defects at the source it could possibly result in reducing the cost of producing defects and ensuring a continuous flow of products through the different processes. Apart from the above, the author would like to emphasise that quality cannot be inspected in a product; however, it should be built into the product. This means that products should be manufactured right first time.

2.6.3.6 5S METHODOLOGY

The 5S methodology is defined as a system for workplace organisation and standardisation (Evans and Lindsay, 2005:177; Gupta, 2005:441; Emiliani and Stec, 2005:373; Liker, 2004:150). It is derived from the Japanese terms as follows: Seiri (sort), Seiton (set in order), Seiso (shine), Seiketsu (standardise), and Shitsuke (sustain). The 5S methodology is used to maintain a safe and clean working environment in the following sequential order:

- Sort – Sort through items in the work station and keep only what is needed while disposing of what is not required.
- Set in Order – Arrange material and equipment so that they are easy to find and use. Create a designated place for all equipment, and that all equipment is placed back in their positions when not in use.
- Shine – Clean everything. The cleaning process often acts as a form of inspection which exposes abnormal and potential pre-failure conditions that could create inferior quality or cause machine failure.
- Standardise – Develop systems and procedures to maintain and monitor the first three S's.
- Sustain – Maintain a stable workplace on an ongoing basis for continuous improvement.

According to Worley and Doolen (2006:230), the 5S approach is based on the philosophy that a clean and organised workplace leads to greater willingness among the employees to perform activities correctly. To illustrate this point, De Koning et al. (2008:4) claim that the 5S methodology requires a total cultural change in an organisation and its focus is to keep the workplace well organised and clean to reduce inefficiencies, errors, defects and injuries. Furthermore, Naslund (2008:275) advises that the 5S methodology builds a culture into the organisation which eases the implementation of other improvement techniques and inadvertently benefits both the employees and the organisation to sustain a healthy working environment in the long term. These authors agree that the assertion of the 5S tools lies with the employees but should be promoted by the management team.

From the above review, it can be gathered that the 5S tool develops a system of procedures for creating a clean and safe working environment within an organisation. Therefore, each pillar of the 5S tool must be implemented correctly as it provides the visibility that is needed in processes and serves as the starting point for any continuous improvement initiative in an organisation. This leads to the conclusion that the 5S tool organises and guides the elements of the manufacturing processes in the organisation to operate efficiently and thus enhance productivity. The 5S tool can be considered the most cost effective tool to implement in an organisation as there appears to be no costs associated with its implementation.

2.6.3.7 CELL MANUFACTURING

According to Bhasin and Burcher (2006:57), Cell manufacturing is a technique that groups selected employees, machines and operational processes into an independent operational unit to manufacture a complete product from start to finish in a single process flow. They claim that the manufacturing cells are arranged in a sequence to support a continuous flow of components through the production process with minimum transport, waiting and processing time. The manufacturing cells provide organisations with the flexibility to manufacture similar products on the production line in response to specific customer demands. This is enumerated by De Koning et al. (2008:5) and Santos et al. (2006:65) who suggest that Cell manufacturing organises a production process to accommodate similar products and rearranges the workspace to optimise it with respect to efficiency. Since the manufacturing cells occasionally share the same work schedule, it becomes complex to manufacture different part families and product groups. Therefore, Shah and Ward (2007:799-800) propose that products be grouped according to product families and equipment be laid out in the sequence of the cells to avoid this complication.

To add to another dimension of Cell manufacturing, Olivella et al. (2008:803) declare that multi-skilled employees are required to operate in this type of environment. They advise that the employee's responsibility shifts from operating a single machine to managing multiple machines in a manufacturing Cell. The employees are expected to inspect the products after each process and perform simple maintenance of the machines. This means that the employees are arranged around families of similar products to perform different functions within the manufacturing Cell and they also take full responsibility for the production unit. From the above, it can be interpreted that since the focus of Cell manufacturing is to manufacture a complete product from start to finish in a single process flow, instant support from management may be needed to assist the employees with problems they cannot resolve to prevent production losses. Because of the free flow of components in a manufacturing Cell, it is evident that this type operation has the ability to produce components in accordance with the JIT production system. Aside from these, there is also the possibility that Cell manufacturing may not be suitable for organisations that have a wide variety of products. Perhaps in these circumstances it can be suggested that manufacturing cells be created to produce sub-assemblies from similar equipment.

2.6.3.8 PRODUCTION LEVELING

In a typical manufacturing environment, Liker (2004:116-117) points out that it is often difficult to accurately forecast customer demands and manufacture products accordingly as customers' do not purchase products in a sequence that can be predicted by the organisation. He believes that there may be a risk of the products not being sold if it is manufactured in excessive quantities while waiting for the customer to place their orders. Therefore, as highlighted by Emiliani and Stec (2005:373), as a possible means of counteracting these situations, the idea of production leveling was created to manufacture products at a constant and predictable rate. They believe that it serves as a tool to reduce fluctuations for planned production schedules of product types and volumes. The organisation analyses the ordering pattern of the customer over a fixed period of time and then incorporates these patterns into the daily production schedule so that they can manufacture smaller volumes of different products over the fixed period of time. Through this technique, the organisation is able to fulfil the customer's order upon request while not manufacturing excessive volumes and product types. It also reduces the risk of products not being sold as the organisation will be flexible to manufacture what the customer orders and in the correct quantities.

Another view of this technique is provided by De Koning et al. (2008:4) who suggest that line balancing can be used to balance and fine tune the processing capacity of each process step to prevent both over capacity and under capacity constraints. They claim that an organisation would enable consistent line balancing and ensure predictable production quantities when the customer specifies minimum batch quantity requirements for any given product. If the production schedule is consistently level, it enables an organisation to effectively produce the correct quantity of products with the efficient utilisation of manpower. Although it may be difficult to manufacture products to actual customer demand, it is evident that the end objective of production leveling is to manufacture products at a uniform rate in a production cycle. Perhaps minimising fluctuation in the production line and providing a level production schedule would ensure that the organisation manufacture products at their required output level. This method would not disappoint the customer as the stock ordered would be manufactured to the standard inventory requirements as prescribed by the JIT production system.

2.6.3.9 TOTAL PRODUCTIVE MAINTENANCE

According to Liker (2004:33), when an operator shuts down equipment to resolve a problem it results in other operations also stopping and thus creating a crisis. He believes at this point there is always a sense of urgency for engaging all levels and functions in production to attend to the problem together and get the equipment operational again. This situation calls for the investment in TPM where all employees learn how to clean, inspect, and maintain the production equipment. Based on the assessed risks and costs associated with equipment failure, Mathaisel (2005:624) contends that TPM was created as a countermeasure for the optimisation of equipment reliability and process productivity. The goal is to address the entire production system lifecycle and develop a shop-floor based system to prevent accidents, defects and breakdowns. Another view of understanding TPM is provided by Emiliani and Stec (2005:373) who declare that TPM is designed to maximise equipment effectiveness through planned predictive and preventive maintenance so that equipment is in good operating condition when required.

For Santos et al. (2006:109) and Gupta (2005:444-445), TPM develops optimal machine conditions to achieve zero breakdown status and extends the economic life span of the machine. The authors concur that achieving zero equipment breakdowns leads to improved utilisation of production assets and plant capacity. Similarly, Shah and Ward (2007:799) advise that the most noticeable aspect of TPM is that it ensures equipment is operational to facilitate a smooth production flow and prevent disruptions in manufacturing. It can be gleaned from the viewpoints of the above authors that to effectively pursue the TPM improvement programme in an organisation, the shop floor employees must be actively involved in the maintenance process of equipment. It is assumed that the employees would only be involved in the daily cleaning and routine maintenance functions of the equipment since specialised maintenance generally require the expertise of the maintenance personnel. In this regard, it may possibly create a sense of ownership towards the maintenance of the machine from the employee’s perspective. The resulting outcome of this technique is that it creates an atmosphere of effective teamwork between departments.

2.6.3.10 SINGLE MINUTE EXCHANGE OF DIES

Bhasin and Burcher (2006:57) outline that the SMED technique is used in a production environment to reduce machine set-up times so that the organisation can maintain a smooth flow of activities between processes. They claim that it converts as many changeover steps as possible while the equipment is functioning so that it can simplify and streamline the remaining steps before changing the machine set-up from one product to another. Based on this idea, Santos et al. (2006:140-145) claim that the SMED technique is extended in a similar fashion to increase productivity and flexibility in operations. They posit that it is possible to achieve effective machine changeover without costly investments as the SMED technique seeks to eliminate the use of screws and nuts as the fixing elements. They further declare that this technique entails arranging the appropriate tools which are required in the set-up process for producing a new part before the machine finishes the preceding lot. By adopting this approach, it results in minimising the amount of time required to change a machines setting.

Adding another view on the SMED technique, Evans (2008:269) suggests that the rapid changeover of tooling and fixtures in the manufacturing environment provides the opportunity for multiple products in smaller batches to be produced on the same equipment. Viewed in this light, De Koning et al. (2008:4) advise that the set-up time reduction seeks to increase the flexibility of production and optimises the utilisation of the production resources by reducing machine downtime. It can be gathered from the viewpoints of the above authors that the SMED technique assists an organisation to improve productivity and provide greater equipment utilisation through the rapid changeover of equipment. Since it has been identified in section 2.6.3.1 that smaller production volumes are required to maintain the JIT production system, it is clear that the SMED technique may be necessary to eliminate delays in the machine change over time and in addition assist the organisation in reducing lead time to improve the product flow.

Each of the tools discussed above reflects a critical disposition towards managing, improving and smoothing the process flow in an organisation. The various authors concur that JIT production provides the required part, in the correct quantity and at the exact point in time; Creating Continuous Flow between Processes ensures that there are no stoppages throughout an organisations processes; Pull Systems manages the customers orders; Standard Processes reduces variation; Quality at the Source prevents defects moving from one workstation to the next; 5S methodology maintains a clean and safe working environment; Cell Manufacturing groups common processes together; Production Leveling generates consistent production volumes; TPM maximises equipment effectiveness and SMED provides rapid changeover of tooling and fixtures. The next section reviews the principle of removing non-value added steps and waste.

2.6.4 REMOVE NON-VALUE ADDED STEPS AND WASTE

The objective of this principle is to identify and eliminate all the non-value added steps and waste that may exist within the various processes of an organisation. From an operational perspective, Morgan and Brenig-Jones (2009:132) contend that in order for a process step to be classified as “value adding”, it should meet the following criteria: is the step important to the customer, does the step either physically change the product or service in some way or is it an essential prerequisite for another step and will the step perform its intended function correctly the first time. In keeping with this, it was considered appropriate to understand how to identify those activities that are regarded as non-value added steps and waste in an organisation. The various authors concur that the Value Stream tool is commonly used for this purpose as it highlights all activities in a process that are needed to manufacture a product or perform a service (Naslund, 2008:274; Gupta, 2005:17; Mathaisel, 2005:629; Keller, 2005:106). They suggest that the Value Stream tool can distinguish all process activities that create Value from those activities that do not create Value in the flow of products or services.

In relation to the above, Chen et al. (2010:1072) and Su et al. (2006:8) state that a “current” state Value Stream map can be useful because it demonstrates existing work processes as they appear so that appropriate investigations can be performed towards the need for change and/or to understand where opportunities for improvement may exist. As highlighted by Starbird and

Cavanagh (2011:67-68), the first step for creating value is to perform a Value Stream analysis by taking a traditional process map and adding critical information about the process onto it to create a single visual picture of the process. Some of the information that is made visible on the Value Stream map includes: identification of the number of employees required for each process, volume flow rate of customer demand, standard operating time to complete each activity, WIP inventory waiting before each process, and information flow to control each task. After the investigations are completed through the Value Stream analysis, the authors indicate that a "future" state Value Stream map would be constructed. This will indicate the opportunities for possible improvement with the intention of achieving a higher level of performance.

From the above review, it can be gleaned that that to effectively create Value in products and services, an organisation needs to identify and eliminate unnecessary steps in the process and prevent all forms of waste. The rationale of eliminating waste is to utilise the minimum amount of available resources that are required to "add value" to the product or service while satisfying the customer's expectations (Morgan and Brenig-Jones, 2009:9; Thomas et al., 2009:114; Gupta, 2005:16). Thus, the aforementioned discussions point to the direction that the Value Stream tool can be effectively used to identify the common sources of waste in a manufacturing system. Pepper and Spedding (2010:139), Evans (2008:268), Santos et al. (2006:7-8) and Liker (2004:28-29) maintain that each of the common sources of waste (overproduction of work in progress inventory, excess warehouse inventory, transportation of components, waiting for preceding processes, motion of unnecessary operations, inadequate processing steps, defects requiring rework and unused employee creativity) can have a significant impact in an organisation. The possible impacts are as follows:

- **Waste of Overproduction** - The waste of overproduction occurs when organisations manufacture more stock than originally planned for or they produce items before it is needed by the next process or the customer. In most cases, overproduction contributes significantly to the other forms of waste such as excessive inventory, commitment of unnecessary storage costs, unidentified defects, or the risk of the stock becoming obsolete in an organisation (Morgan and Brenig-Jones, 2009:136; Santos et al., 2006:4; Liker, 2004:29).
- **Waste of Waiting** - This type of waste surfaces whenever goods are not moving between processes or being processed. It is a type of waste that occurs when employees are unable to process their tasks due to equipment failure or when they have to wait for a preceding

or proceeding process cycle to be completed (Morgan and Brenig-Jones, 2009:137). Employees who stand idle and watch an automated machine that produces components or a proceeding process that fails to deliver parts needed in the present process result in time being wasted (Santos et al., 2006:8; Liker, 2004:28).

- **Waste Of Transportation -** The waste of transport refers to unnecessary movement of material from one location to another in a manufacturing system. Rawabdeh (2005:806) contends that since components are generally transferred from a large batch to smaller batches or are moved several times from one machine to another during processing, they are likely to result in damage and deterioration. This double handling from larger to smaller batches, excessive movement and temporarily storing activities lead to transportation waste.
- **Waste of Inappropriate Processing -** The waste of inappropriate processing is the result of employees who perform unnecessary processing steps in the product flow (Morgan and Brenig-Jones, 2009:137). This type of waste is commonly encountered in environments where there are limited standard operating procedures available for the employees to perform their tasks. In certain situations, Liker (2004:29) claims that problematic tools and processes which are incapable of producing quality goods are likely to result in inappropriate processing. These tools and processes forces the employees to move unnecessarily and results in defects being produced.
- **Waste of Inventory -** The waste of inventory is an accumulation of finished products, work in progress stock and raw materials that remain unused at different stages in an organisation (Morgan and Brenig-Jones, 2009:138). It results in higher production imbalances, consumes physical space, creates financial implications and increases the possibility of damage and deterioration (Koumanakos, 2008:356; Naslund, 2008:275; Rawabdeh, 2005:806; Liker, 2004; 29).
- **Waste of Motion -** The waste of motion refers to the ergonomics for quality and productivity which consumes both time and energy in a manufacturing process. This type of waste emerges in the actions of employees as they search for tools and parts because they are kept out of the immediate reach of the workstation. In this way, much time is spent walking among machines and work stations to locate these items (Morgan and Brenig-Jones, 2009:138; Liker, 2004:29). Rawabdeh (2005:806) claims that another form of waste results from non-standardised work methods. This is a common form of motion waste where work processes are not standardised and therefore employees work to their

own views. It results in excessive work in progress stock and higher percentage of defects.

- **Waste of Defects -** The waste of defects stems from poor quality work that results in rework, scrap and additional inspection. All of these activities impose additional handling, time and effort which interfere with productivity and stops the smooth flow of the production process (Santos et al., 2006:7; Liker, 2004:29). The consequence of manufacturing defects requires investigating materials, equipment and labour in something that cannot be sold and is claimed to be the worst offense against cost reduction (McCarty and Fisher, 2007:195; Bendell, 2006:258).
- **Waste of Untapped Human Potential -** The waste of untapped human potential refers to the ideas, skills, improvements and learning opportunities that are lost by not engaging or listening to the employees (Liker, 2004:29-33). Lee and Peccei (2008:9) accentuate that employees are likely to perform at their best to achieve quality goals set by management when they feel acknowledged and they are treated fairly for their contributions. Since employees are the main asset of an organisation, it is important to respect their opinions regarding improvement opportunities.

Going one stage further, Rawabdeh (2005:805) suggests that there exists a relationship between each of the wastes above and provides an illustration in Figure 7 to describe this relationship.

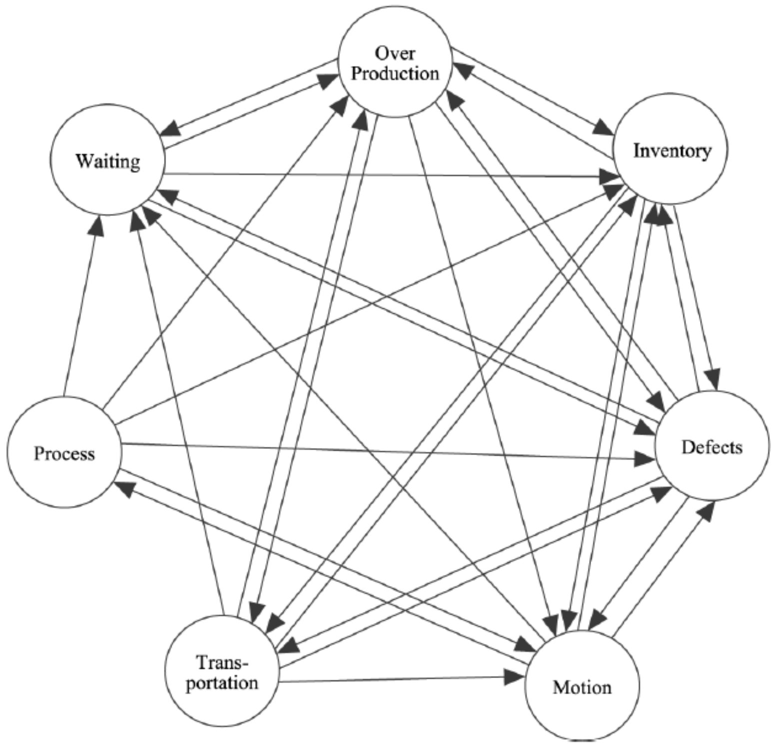


Figure 7 – Direct waste relationship (Adapted from Rawabdeh, 2005:805)

It can be observed in Figure 7 that overproduction is directly proportional to inventory, defects, motion, transportation and waiting. Although Figure 8 reveals that each waste is directly linked to another, certain wastes have a stronger impact on others whilst there are some that have very little influence on another; this is indicated by the direction and number of arrows going into or out of a source of waste. For example, overproduction has a stronger relationship with inventory and defects but a weaker relationship with motion and processes. In practice, Rawabdeh (2005:803) indicates that it may be difficult to identify the various sources of waste due to the numerous parameters and overlap that lies between the different processes. Lee-Mortimer (2006:265) highlights that organisations which take a wider focus on Lean often discover hidden wastes even in the most effective Lean operations. Based on these insights and from a more fundamental perspective, McCarty and Fisher (2007:191) are of the view that wasted effort and errors are often hidden in everyday operations such as delayed response time, multiple rework loops and inaccurate data. Under these circumstances, it has been noted by Taj and Berro (2006:335) and Taj (2005:629) that even the best Lean organisations waste approximately thirty percent of their available resources. Hence, it can be surmised that although the task of identifying waste is not easy, employees should be made aware of the waste activities that could be concealed between their processes. The focus of the above discussions indicates that some wastes are influenced by each other and therefore it can be suggested that reducing one waste, could possibly lead to the reduction or elimination of the others. After providing some in-depth explanation and various opinions and points of views on reducing non-value added steps and waste, the proceeding section of the literature review will discuss the principle of managing by fact and reducing variation.

2.6.5 MANAGE BY FACT AND REDUCE VARIATION

The concept of managing by fact and reducing variation refers to the statistical tools that are deployed in an organisation for managing processes so that effective decisions can be made based on reliable and accurate data obtained during product and process improvements (Haikonen et al., 2004:370). Based on this rationale, the various authors concur that the statistical tools are commonly used to investigate the value stream for sources of variation which influence the process (Evans, 2008:266; Andersson et al., 2006:287; Antony, 2006:240; Evans and Lindsay, 2005:41; Keller, 2005:106). They highlight that process control charts are used to manage and interpret process data accurately as a means of understanding variation that may be present in a process. The process control charts are used as a notification to signal when to take action on a process that has the potential to deviate from the specification. To this end, Naslund (2008:271) asserts that the statistical tools enable an organisation to initially understand fluctuations in a process and then can help to identify the root cause of the problem.

Adding another dimension on variation, Nakhai and Neves (2009:670) caution that variation in a particular part of an operation will have a potential impact throughout the remainder parts of the operation. Therefore, given the important role that statistical tools play in quality improvement in contemporary business and industry, Morgan and Brenig-Jones (2009:24) advise that the statistical tools can frame the overall strategy for quality management through the use of reliable and accurate data in problem solving. In addition, Nauhria et al. (2009:37) is in agreement with Schroeder et al. (2008:544) that focusing on reducing the root causes of variation from a process and undertaking improvement tasks systematically ensures that the organisation does not generate inadequate conclusions that may have a negative impact on the customer. Taking this view further, they suggest that the organisation should have significant measures in place to ensure that the investigation areas are measured correctly. This means that data collection should not be an arbitrary process as key decisions depend on the information that is collected.

The aforementioned views are consistent with Foster (2010:444) who contends that the statistical tools can focus on actions to reduce variation and offers the opportunity to challenge the given by investigating breakthrough solutions through idea generation and experimentation. To validate this argument, Nair et al. (2011:529) found that the objective of statistical tools, along with other problem solving tools, serve as the technical foundation for quality control issues that underpin process improvement. They claim that reliable and accurate data provides the means to quantify and verify the possible causes of variation in a process. It should be noted that variation in a process could possibly lead to unnecessary waste and inefficient operations which would result in excessive quality costs that impact the competitiveness and profitability of an organisation. Therefore, it can be interpreted from the discussion above that an organisation which uses reliable and accurate data for problem solving will make effective decisions towards the improvement. The increasingly volatile manufacturing environment has made it imperative for management to provide the tools and training to assist employees in understanding process variation and gathering accurate data for process improvement. Thus, the next section will present an overview of the key personnel that are required in a Lean Six Sigma environment.

2.6.6 INVOLVE AND EQUIP THE PEOPLE IN THE PROCESS

In today's dynamic business environment, Schroeder et al. (2008:544) recommend that organisations establish clear roles and responsibilities before embarking on any improvement process. They believe that allocating clear roles and responsibilities to employees would ensure better control of activities in a project. In this regard, the various authors contend that the Lean Six Sigma infrastructure is made up of senior management leadership and specialists that are referred to as Champions, Master Black Belts (MBB), Black Belts (BB) and Green Belts (GB) (Snee, 2010:20; Delgado et al., 2010:517; De Koning et al., 2008:7). They claim that each of these specialists is required to perform certain activities as part of the Lean Six Sigma improvement project. These individuals receive extensive education and training in Lean Six Sigma tools and project management skills. They are expected to excel in skills such as understanding how to measure and collect data with both Lean and Six Sigma tools and how to accurately identify the needs of the customers and the processes that are critical to quality. An overview of the roles and responsibilities of these specialists is presented in Table 4 to gain a broader understanding of their contribution in a Lean Six Sigma organisation.

(i) Champions	(a) Establishing the Lean Six Sigma programme, its vision, path and training plan across the organisation
	(b) Establishing Lean and statistical-based thinking in the organisation
	(c) Selecting high potential Lean Six Sigma projects
	(d) Inquiring MBB and/or BBs on the status and focus of the Lean Six Sigma projects
	(e) Establishing organisational culture and allocate infrastructure for achieving cost benefits through the execution of Lean Six Sigma projects
	(f) Employing the suggestions of the MBB and BBs that enhance cost benefits and organisational leadership
	(g) Recognizing the endeavors of the members involved in the Lean Six Sigma projects
(ii) MBBs	(a) Focusing Lean Six Sigma projects towards achieving organisational objectives and associating with the champion while executing Lean Six Sigma projects
	(b) Designing and executing Lean Six Sigma belt training programmes to suit the needs of every Lean Six Sigma project in the organisation
	(c) Aiding during Lean Six Sigma project identification
	(d) Mentoring BBs in Lean Six Sigma projects
	(e) Involving in the project reviews to suggest the adoption of right Lean Six Sigma tools and techniques
	(f) Guiding eligible members to get certified as BB
	(g) Creating environment for facilitating the communication of the most excellent practices across the organisation
(iii) BBs	(a) Performing professional activities in accordance with champion's vision
	(b) Identifying the barricades and aiding the project teams to overcome those barricades
	(c) Informing improvements to suitable managerial personnel
	(d) Seeking assistance from the champion when needed
	(e) Influencing informally the fruitful execution of Lean Six Sigma projects
	(f) Validating the employment of most valuable Lean Six Sigma tools and techniques
	(g) Setting up an in depth project assessment method during the measurement phase
	(h) Obtaining contributions from well-informed operators, foremost supervisors and team leaders
	(i) Managing Lean Six Sigma project threats
	(j) Ensuring sustainment of the DMAIC outcomes
(iv) GBs	(a) Involving in the Lean Six Sigma project teams in the accordance with their existing responsibilities
	(b) Gaining knowledge of the Lean Six Sigma methodology pertaining to the project
	(c) Becoming skilled to apply Lean Six Sigma tools and techniques during and after the implementation of the project

Table 4 – Roles and responsibilities of Lean Six Sigma personnel (Adapted from Karthi et al., 2011:313; Foster, 2010:428; Montgomery, 2010:62; Montgomery and Woodall, 2008:333; Schroeder et al., 2008:541; Savolainen and Haikonen, 2007:10; McCarty and Fisher, 2007:192; Evans and Lindsay, 2005:56-57; Haikonen et al., 2004:372-373)

It can be inferred from Table 4 that the Champions are senior level managers who promote and lead the deployment of Lean Six Sigma in a predefined area of the business. The functional role of a MBB is a full time specialist who is responsible for planning the Lean Six Sigma project, mentoring the team members, managing the deployment and providing the results. The BB's are generally full time change agents who are removed from their routine operational responsibilities of the organisation and are expected to deploy Lean Six Sigma projects. From Table 4, it is evident that the BB bridges the gap between management and improvement teams. Lastly, Table 4 reflects that the GB's conduct basic analyses of data and provide ideas for improvement.

Apart from the designated improvement specialists highlighted above, Thevnin (2004:199) believes that all employees have their own unique role to fulfill in an organisation. He claims that each employee's individual role must be recognised and appreciated so that everyone works towards a common goal. To a great extent McCarty and Fisher (2007:190) make a distinction where employees and processes are inseparable. They point out that employees do not intentionally produce poor quality work; but due to inefficient processes that produce inadequate standards of work it creates a poor reflection of the employees' performance. To address these concerns, Mehrjerdi (2011:81) recommends that organisations invest in new technology as a means of improving processes so that the employees can produce a high standard of work. Based on this idea, Starbird and Cavanagh (2011:78-79) stress the necessity of including all employees during the implementation of new technologies as a means of gaining their acceptance for changes that may occur in their existing processes.

It can be interpreted from the viewpoints of the above authors that employees and processes should be integrated into an environment that creates and sustains relationships of trust, support, interdependence and collaboration. It is important to involve the employees in process improvements and provide them with the appropriate tools for challenging their processes and the way they work. Morgan and Brenig-Jones (2009:165-166) claim that the Lean Six Sigma program should not make the employees feel threatened towards job losses; however, it should serve as a guide towards making appropriate changes that are required to improve the processes of the organisation. It is thus worth noting that the fundamental challenge for the organisation is to create a supportive culture where employees assist each other and work in teams. Engaging employee's actively in organisational changes, captures the creativity, energy and ideas from everyone in the organisation and allows for decisions to improve significantly through this collaboration. Also, by empowering employees, it is anticipated that the organisation would gain a more competitive workforce which would help to pursue continuous improvement on an ongoing basis. An overview of continuous improvement is presented next.

2.6.6.1 CONTINUOUS IMPROVEMENT

According to Bhuiyan and Baghel (2005:761) and Comm (2005:65), continuous improvement is a technique that focuses on employees working together to make ongoing improvements to their processes. It is a series of actions taken to identify, analyse and improve existing processes within an organisation to meet new goals and objectives. Given the prominent role that continuous improvement plays in quality and process improvement, Schonberger (2007:405) believes that it should be applied to all products, processes and services as it provides successful strategies to improve the performance of an organisation. Based on this idea, Anand et al. (2009:445-450) assert that the continuous improvement initiatives can assist the organisation in integrating operational processes to make cohesive and quick process changes to improve performance. They claim that the continuous improvement infrastructure should consist of a purpose towards the organisation, the processes that have been identified for improvement and the involvement of the employees.

Adding another view on continuous improvement, Nauhria et al. (2009:35) recommend that the organisation should first concentrate on getting the processes consistent and then seek additional improvement opportunities. The point to understand, according to Sim and Rogers (2009:46), is that continuous improvement is about change and requires employees to work with a different mindset. They believe that the best process improvement ideas reside in the front line employees and when goals are established through the interactions with upper management, it serves as a motivation to encourage the employee's initiatives towards continuous improvement. This means that that a total organisational culture change is required to promote organisational learning and continuous improvement. This is supported by Salah et al. (2010:249-250) who document that the success of continuous improvement depends on how it is implemented and maintained within an organisation. Viewed in this light, it can be interpreted from these authors that continuous improvement could be seen as one way of possibly challenging the employees to experiment and learn more about their processes.

Some of the common tools that are deployed for continuous improvement include the suggestion scheme programme, Kaizen and the PDCA methodology. In terms of a suggestion scheme programme, Santos et al. (2006:1) and Bhuiyan and Baghel (2005:766) accentuate that employees are encouraged to concentrate on problem areas and find the best possible solutions since suggestions generally provide cash rewards and motivation. On the other hand, Chen et al.

(2010:1071) and Mathaisel (2005:639) document that Kaizen is a Japanese term for continuous improvement which means incremental improvement and is a key strategy to implement the "support-the-worker" principle. To demonstrate the practicality of the Kaizen approach, Starbird and Cavanagh (2011:18) point out that it is associated with small process improvements that are discovered and implemented by teams of employees. The PDCA cycle is regarded as the cornerstone of continuous improvement. Within the context of a production environment, Liker (2004:264) explains that the PDCA cycle relates to creating a one piece flow, surfacing problems as they appear, establishing counter measures and evaluating the results to sustain the improvement.

In general, it can be interpreted that the word continuous means ongoing, hence the continuous improvement process never stops. This involves creating a culture in the organisation that engages all employees to enhance productivity and free up the capacity with a stable foundation to pursue innovation and growth on an ongoing basis. It is perhaps ironic that continuous improvement in traditional organisations concentrate mainly on work improvement in the production environment whereas the modern day continuous improvement initiatives are associated with organised and comprehensive methodologies for the entire organisation from top management to employees on the shop floor. From the above viewpoints, it can be interpreted that continuous improvement is the cornerstone of perfection and this can be regarded as a critical element to sustain the Lean Six Sigma effort. In this regard, Shah et al. (2008:6683) espouse that the Lean Six Sigma technique engages employees to continuously improve their processes on an ongoing basis. Therefore, emphasis can be placed on viewing continuous improvement as an exciting and rewarding journey that can keep an organisation ahead in today's highly competitive market. After providing some in-depth explanation on involving and equipping the people in the processes accompanied by continuous improvement, the next section of the literature review investigates the principle of undertaking improvement in a systematic way.

2.6.7 UNDERTAKE IMPROVEMENT IN A SYSTEMATIC WAY

Various authors are in agreement that the DMAIC cycle is commonly used as a foundation for supporting the Lean Six Sigma technique because it facilitates the investigation of improvement projects systematically (Barnes and Walker, 2010:26; Salah et al., 2010:254; Snee, 2010:19-20; Delgado et al., 2010:518; Thomas et al., 2009:114; Chen and Lyu, 2009:449; Morgan and

Brenig-Jones, 2009:25-26; De Koning et al., 2008:7; De Koning, De Mast, Does and Vermaat, 2008:32). It is a closed loop process that eliminates unproductive steps and encourages creative thinking about a problem and its solution.

Karthi et al. (2011:312) outline that Lean tools are generally incorporated into each step of the DMAIC cycle and have been shown to improve the flow of processes while reducing defects concurrently. Against this background, Salah et al. (2010:265) point out that the DMAIC structure is robust and flexible to identify both the appropriate personnel and tools that are necessary for improvement projects. An overview of each phase of the DMAIC cycle is as follows:

- **Define Phase** – The goal of the Define phase is to set the stage for the project's purpose and scope by obtaining background information about the process and its customers. If the Define stage is not clearly evaluated in terms of customer satisfaction and internal process improvement it could result in the solution not being effective with respect to the project objectives. Therefore, Mehrjerdi (2011:80) and Starbird and Cavanagh (2011:25) assert that the VOC is usually evaluated before investigating the effects and scope of the problem. The tools and techniques that are used in the Define stage are summarised in the project charter to provide an outline of the entire project (Antony, 2006:239; Evans and Lindsay, 2005:81; Gupta, 2005:166). At the end of the Define phase, the team has a clear project charter to proceed with the remaining steps of the DMAIC cycle.
- **Measure Phase** – The goal of the Measure phase is to gather information about the existing situation of the process. This phase investigates which factors or inputs have the most significant influence on the process and consequently decides how to measure them (Foster, 2010:435; Evans, 2008:265; Andersson et al., 2006:287; Antony, 2006:240; Evans and Lindsay, 2005:40). Montgomery and Woodall (2008:338) reveal that it is vital to understand what to measure and how much of the data is required for analysis so that the process performance can be evaluated. Typical questions such as what are we trying to answer, what type of data will we need, where can we find the data, who can provide the data and how can we collect the data should be considered for the investigation. The sequence for the measure phase entails defining the key metrics for all CTQ characteristics and then establishing what aspects of the problem need to be measured (Mehrjerdi, 2011:82; Antony, 2006:240; Evans and Lindsay, 2005:124).

- **Analyse Phase** – The goal of the Analyse phase is to identify the root causes of variation and confirm them with the data gathered (Mehrjerdi, 2011:82; Foster, 2010:443; Evans, 2008:266; Andersson et al., 2006:287; Antony, 2006:240; Evans and Lindsay, 2005:41; Keller, 2005:106). Since all operations are interconnected and variation may be prevalent in all processes, Montgomery and Woodall (2008:339) recommend separating the common causes of variation from the assignable causes of variation during the investigation. The analyses should include examining patterns, trends, and changes over time to understand the relationships among the different metrics (Antony, 2006:240). The deliverables of this phase is a theory of the cause and effect relationship that has been tested and confirmed by the project team (Przekop, 2006:75; Gupta, 2005:227).
- **Improve Phase** – The goal of the Improve phase is to develop and implement solutions that address the root causes of the problem and to establish a more efficient process (Montgomery and Woodall, 2008:340; Andersson et al., 2006:287; Antony, 2006:240; Gupta, 2005:99). Mehrjerdi (2011:82) and Foster (2010:444) stipulate that this phase focuses on actions to reduce variation and offers the opportunity to challenge the given by investigating breakthrough solutions. The resulting outcome in this phase is that the project team generates creative ideas for resolving the problem and makes the necessary adjustments to the process for improving the performance of the CTQ's (De Koning et al., 2008:6; Evans and Lindsay, 2005:41).
- **Control Phase** – The goal of the Control phase is to maintain the gains that have been made by standardising the work methods or processes, anticipating future improvements, and preserving the lessons that are learnt from the effort (Evans, 2008:266-267; Andersson et al., 2006:287; Antony, 2006:240; Evans and Lindsay, 2005:42; Gupta, 2005:323). Mehrjerdi (2011:82) concurs with Keller (2005:156) that the predicted impact of the improvements and the project deliverables must be continually verified, especially the financial return and lessons learned. Although the chosen solution might be effective, De Koning et al. (2008:6) encourage that a post intervention baseline study should be conducted to assess the effectiveness of the proposed improvement. The responsibility for control and adjustment of the new improvement is allocated to the appropriate process owners and senior management should be informed of the project results. Schroeder et al. (2008:542) point out that the process owners should take a more active role in the control phase.

Regarding the above, Schroeder et al. (2008:544) contend that by following each step of the DMAIC cycle consistently ensures investigations for a problem are confirmed with accurate data and alternative solutions are reviewed before sustaining the improvements. They believe that the DMAIC cycle supports an analytical approach to problem solving so that the organisation can quantify improvements and find solutions to complex problems. One possible application is proposed by Jenicke et al. (2008:458) who suggest that the DMAIC cycle can be used to achieve the desired levels of performance by selecting improvement projects that are aligned with the strategic objectives of the organisation. They advise that strategic improvement projects optimise production processes with high yields. In operation, Chen and Lyu (2009:445) propose the use specific Project Management, Quality, Lean and statistical tools at each phase of the DMAIC cycle to achieve the expected outcomes of each phase effectively. It can be interpreted from the discussion above that each phase of the DMAIC cycle provides a roadmap to sustain effective process improvement and helps the organisation to solve problems consistently from start to the finish. A summary of the Lean Six Sigma principles that were discussed in this section is presented next.

It is evident in this section that the principles which make up the Lean Six Sigma technique have been constructed from the main objectives of Lean and Six Sigma standalone systems. The first principle which focuses on the customer stems from Lean concentrating on delivery time and Six Sigma acknowledging the CTQ's. The views of Delgado et al. (2010:518) are aligned with Snee (2010:20) who identify that the customers and the stakeholders benefit significantly through the Lean Six Sigma initiative. The second principle considers the similarities identified in both Lean and Six Sigma which specifies going to where the action takes place. The third and fourth principle relates to the Lean approach which considers Flow and Value added activities. The fifth principle defines the constructs of the Six Sigma approach to manage by fact and reduce variation. The sixth principle considers both approaches which dictate the involvement of all employees in the improvement of processes. Lastly, the seventh principle culminates from the Six Sigma structured methodology of undertaking improvement in a systematic way. The next section highlights some of the challenges that organisations experienced through the Lean Six Sigma technique.

2.7 LEAN SIX SIGMA CHALLENGES

This section highlights some of the challenges identified by organisations which implemented the Lean Six Sigma technique.

Although Lean Six Sigma is still at an early stage of practice across the world, generally to great positive acclaim and results, there are some challenges that have been identified in the system. For example, in terms of the way in which Lean Six Sigma is implemented in an organisation, Delgado et al. (2010:520) present the following limitations that could be perceived as weaknesses in the system. These are:

- The balance between routine work and the work involved in Lean Six Sigma training and projects;
- The broad set of tools available in Lean Six Sigma and the inability to select the most appropriate ones to achieve business reality;
- The inability of some employees to acquire the necessary understanding in mathematical and statistical nature of some tools;
- The long time necessary for some projects to be fully developed and to produce results can reduce the motivation felt by employees.

Considering the point on statistics as highlighted by Delgado et al. (2010:520), Pepper and Spedding (2010:148) cite specific cases by Mika (2006) where the statistical tools of Lean Six Sigma cannot be embraced by the average employee on the shop floor. They claim that specialists are needed to use statistical tools as indicated in section 2.3.2. Similarly, Laureani and Antony (2010:689) suggest that this technique is less spread in the service sector due to the service industry not utilising the rigorous set of statistical tools. Another view on the downside of statistics is presented by Thomas et al. (2009:116-117) where management and employees in smaller organisations generally have insufficient theoretical knowledge to see the potential benefits of statistical tools. They cite cases by Thomas and Webb (2003) where smaller organisations reflected the limitation of intellectual and financial capacity as the primary issues that lead to poor systems implementation.

De Koning et al. (2008:16) found that Lean Six Sigma is not easy to implement in organisations that are culturally not used to process innovation. He believes that a fundamental change in the organisational cultural mindset is needed to sustain the Lean Six Sigma technique. Similarly, the opinion of Snee (2010:18-20) suggests that the employees generally do not understand the objective of Lean Six Sigma and do not believe that it will work. The employees may view Lean Six Sigma as another quality tool and do not recognise the need for change. The common symptom that relates to this challenge is the limitation of roadmaps and poor improvement projects that are selected to sustain the efforts. Although education can help, it appears that successful improvement projects are usually the most effective means to demonstrate to the employees the benefits of Lean Six Sigma and the reason why change is needed.

For Starbird and Cavanagh (2011:52), Lean Six Sigma works well for managing processes but not so well for managing people. They point out that managers in general manage the employees, and it is even more beneficial when the employees have the ability to self manage. Therefore, improving the process will only achieve certain limits and at some point the organisation will have to drive for the right performance of employees with the process. However, these authors further acclaim that Lean Six Sigma is highly effective and can be accomplished with the right organisational infrastructure. It can be gleaned from the discussion above that without the employees "buy-in" and a change in their attitude and behaviour for the implementation of the Lean Six Sigma technique, the organisational efforts for deployment may be unsuccessful.

From a strategic perspective, Hoerl and Gardner (2010:30-33) argue that Lean Six Sigma is not effective in identifying the key changes occurring in the external environment or developing ideas for new products or services. Although it cultivates and utilises creativity, it does not identify opportunities to innovate at the business level. Lean Six Sigma improves existing processes and can identify opportunities for incremental innovation; however, it is not designed to develop the best ideas for radically new products or services. These authors contend that if Lean Six Sigma is viewed as a rigorous application of the scientific method, then innovation needs to be considered for the specific problem or question at hand.

Taken to its conclusion, the views of Starbird and Cavanagh (2011:52) and Snee (2010:18-20) regarding people issues concurs with De Koning et al. (2008:16) who posit that culture plays a vital role in the Lean Six Sigma initiative. These views reinforce the point that organisational change must occur to fully accomplish the objectives of Lean Six Sigma. After highlighting some of the Lean Six Sigma challenges, the last section of this chapter presents an overview of the critical success factors that are required to implement the Lean Six Sigma technique.

2.8 LEAN SIX SIGMA CRITICAL SUCCESS FACTORS

The aim of this section is to explore the critical success factors that are required for implementing and sustaining the Lean Six Sigma technique.

For the Lean Six Sigma deployment to yield perceived results, Snee (2010:11) states that many elements must be considered, aligned and acted upon. He claims that it should include the integration of human and process elements of improvement, a clear focus on getting bottom line results and a method that sequences and links improvement tools into an overall structured approach. He believes that when these three elements are combined with other aspects of Lean Six Sigma, it would produce its successful deployment in an organisation. Therefore, in a similar contribution to Snee (2010:11), Delgado et al. (2010:514-519) summarise the possible critical success factors in Table 5 that may be required for implementing and sustaining the Lean Six Sigma technique.

Lean Six Sigma - Critical success factors
Management commitment
Strategic focus
Change in organisational culture and structure
Integrated people and systems approach
Involvement and participation
Integrated training and development
Recognition and reward systems
Measuring the success in terms of financial benefits
Effective use of technology
Significant project selection

Table 5 – Lean Six Sigma critical success factors (Adapted from Delgado et al., 2010:514-519)

From Table 5, it is evident that management commitment surfaces as top priority in the current business perspective. This is required to drive the elements in the process of changing the organisational culture and influencing the training of key elements in the organisational structure. The managerial commitment has to oversee the implementation of Lean Six Sigma by removing obstacles, allocating financial and human resources to the effort, regularly reviewing its progress, and ensuring appropriate recognition and rewards for the employees (Snee, 2010:21). An encouraging outcome of Lean Six Sigma training is that it should focus on combining training with real improvement projects and not academic exercises because the former produces immediate financial and business results that pay for the training. For enhancing the effectiveness of the training, it is recommended that participants undertake strategic organisational projects that link to business priorities and make the training useful to yield improvements.

In support of the involvement and participation of employees highlighted in Table 4, Morgan and Brenig-Jones (2009:199) advise that teamwork and support should be made available for all employees across the organisation through an internal network. These views are aligned with Delgado et al. (2010:520) who contend that Lean Six Sigma has a direct impact on how employees perform their daily tasks. It is therefore recommended that managers understand employees and their characteristics and help them to realise the importance of the change in their work conditions that is brought by Lean Six Sigma. Another view of understanding the Lean Six Sigma success factors is provided by Snee (2010:25) who is in agreement with Hoerl and Gardner (2010:33-35) that innovation is also required in the Lean Six Sigma theory to continually challenge and enhance the organisation's processes. They claim that if Lean Six Sigma is driven as a continuous improvement and incremental innovation initiative, the organisation will improve quality and business results over time and set the stage for breakthrough innovation. Viewed in this light, De Koning et al. (2008:15) provide strong empirical support that Lean Six Sigma requires an appropriate infrastructure in place for managing incremental innovations.

Based on the rationale above, it can be surmised that the literature relating to the Lean Six Sigma transformation can be broadly divided into operational, cultural and strategic elements. Therefore, with the intention of developing a suitable Lean Six Sigma framework for the automotive component manufacturers in KZN, the recommendations that are proposed by the various authors have been collated and are reflected in Table 6. These recommendations will be accessed during the design of the framework in this study.

Author	Lean Six Sigma Framework Deployment Recommendation
Karthi et al. (2011:326-328)	Advise that Lean Six Sigma is highly compatible with ISO 9001:2008 and recommend that it should be implemented through ISO 9001:2008 to ensure that the systematic continual improvement is achieved in the contemporary business. Their study identified that this approach resulted in less time spent and fewer resources required during the implementation.
Salah et al. (2010:251)	Draw on the results of previous studies and advise that Lean and Six Sigma should not be implemented in parallel or one after the other as it will result in problems such as prioritisation issues, resource allocation, selecting the correct methodology and proving financial gains. They recommend that both techniques should be integrated to leverage their synergy.
Pepper and Spedding (2010:149)	State that the key considerations for designing a Lean Six Sigma framework should include a strategic and process focus, the framework should be balanced between the two philosophies to harness the recognised advantages of both, a balance between complexity and sustainability must be reached, and it should be structured around the type of problem being experienced.
Nauhria et al. (2009:39)	Detail that a well implemented ERP system should serve as the foundation on which an effective Lean Six Sigma program can be established. It collects real time data and provides the information support for Lean and Six Sigma initiatives that focus on waste elimination and variability minimisation.
Thomas et al. (2009:116-117)	Recommend developing a framework that consists of a cost effective approach, a system that integrates the strategic and operational characteristics, and measures in place to directly attack the CTQ problems.
Evans (2008:270) and Evans and Lindsay (2005:178)	State that organisations should start with basic lean principles and evolve toward more sophisticated Six Sigma approaches.
Bhuiyan and Baghel (2005:765)	Document that Lean Six Sigma has been deployed in parallel in some organisations while there are some organisations that focus on Lean Six Sigma as a single technique for improvement. They document under the Lean Six Sigma technique, Lean seeks to reduce waste first which then allows for variations to be spotted more easily.
Gupta (2005:3)	Advise that Six Sigma quality came first. The logic was to do it right first, and then proceed to do it faster. The logic of this scenario for completing tasks faster before learning to do it right, would result in creating waste faster.

Table 6 – Recommendations for Lean Six Sigma framework

It is noted in Table 6 that there are considerable differences among the authors regarding the deployment of Lean Six Sigma. Some authors agree on the consequence of a sequential deployment where Lean organisations start to adopt Six Sigma practices or Six Sigma organisations start to adopt Lean practices (Evans, 2008:270; Evans and Lindsay, 2005:178; Bhuiyan and Baghel, 2005:765; Gupta, 2005:3). Nauhria et al. (2009:39) highlight the need for an Enterprise Resource Planning (ERP) system, while Pepper and Spedding (2010:149) and Thomas et al. (2009:116-117) point out the strategic and operational requirements for implementing Lean Six Sigma. Although Salah et al. (2010:251) advise that the integration of

Lean and Six Sigma should not be implemented in parallel or one after the other, Karthi et al. (2011:326-328) recommend deploying Lean Six Sigma through a management system. There is consensus between Snee (2010:21) and Delgado et al. (2010:514-519) that management commitment and training are key requirements to drive the Lean Six Sigma approach. The recommendations of Delgado et al. (2010:514-519) regarding the critical success factors that are needed for Lean Six Sigma are aligned with Snee (2010:11). Although the views of Morgan and Brenig-Jones (2009:199) identify teamwork and support requirements, Delgado et al. (2010:520) highlight the need for management to have a deeper understanding of employees to promote the Lean Six Sigma technique. Based on the recommendations presented by the above authors, this study will investigate the proposed methods along with the results obtained from the KZN business climate to design a Lean Six Sigma framework for this study. The next section presents a summary of this chapter.

2.9 SUMMARY OF THE CHAPTER

This chapter demonstrated the key focus areas of Lean and Six Sigma and reviewed their strengths and weaknesses as standalone improvement techniques. Thereafter, the gaps that were highlighted from these two techniques were used as the means for critiquing the commonalities that exist between Lean and Six Sigma. The commonalities that were identified provided the justification for combining Lean and Six Sigma into an integrated business improvement technique. Based on the investigations available in literature, the proposed principles which culminate in the critical requirements needed for the Lean Six Sigma initiative to be successful were discussed. In addition, an overview of some the challenges that hinder the Lean Six Sigma initiative was highlighted. By building on previous research, the various considerations regarding the development of a Lean Six Sigma framework were extracted from the different authors and highlighted in this section to guide this study. The concluding remarks emphasised that the Lean Six Sigma technique requires a total organisational, structural and cultural change (Corbette, 2011:128; Salah et al., 2010:253). Regarding the investigations available in literature and considering the need for empirical data that would reveal the KZN context of Lean and Six Sigma integration, a survey is conducted within the DAC. The next chapter presents the methodology that will be adopted in this research to achieve the study objectives.

CHAPTER 3

DESIGN OF RESEARCH AND METHODOLOGY

3.1 INTRODUCTION

The preceding chapters reviewed the introduction and problem statement of the research followed by the critique and insights of the literature review on Lean, Six Sigma and Lean Six Sigma. From a methodical standpoint, Sekaran (2006:5) declares that business research is an organised and systematic investigation process that is employed to accomplish the key objectives of the research undertaken. Therefore, the objective of this chapter is to provide an account of the options and techniques that are available for conducting research and to explain how the research process was developed for this project. The chapter starts by exploring the concept of the research design and demonstrates, with the aid of a flow diagram, the research process that was used in this study.

This chapter also discusses in detail the design of the data collection instrument, the scope of the sample in which this study was undertaken and the validity, reliability and practicality checks that were performed to sustain the credibility of the study. In addition, the chapter provides an overview of the results obtained from the pilot test and highlights the necessary changes that were made to improve the credibility of the measuring instrument. The chapter concludes with an overview of the various statistical methods that were adopted to analyse the data collected for the main study. It should be noted that throughout each section of this chapter, the author substantiated the criteria that were used to select the methods that were adopted in this study along the research journey. An introduction to the main study is also presented in this chapter.

3.2 RESEARCH DESIGN

The research design serves as the scientific foundation that connects all activities involved in a research project. It provides a logical sequence of activities that links a study's initial research question and the plan of investigation that should be employed to obtain the empirical evidence from which conclusions towards the study can be drawn (Yin, 2009:26). Thus, the establishment of a research design bridges the likelihood of any gaps that may exist between fulfilling the study objectives and implementing the research (Terre Blanche, Durrheim and Painter, 2006:34; Blumberg, Cooper and Schindler, 2005:64).

The process of selecting an appropriate research design may be complicated due to the large variety of methods, techniques and procedures available. Despite this variety, Blumberg et al. (2005:64) advise researchers to create a research design that uses diverse methodologies in order to achieve greater insight of the problem context instead of following the most frequent methods. In this regard, Terre Blanche et al. (2006:57) propose that the research paradigm, the purpose of the study, the techniques employed and the situation within which the observation takes place are the four critical aspects that should be considered during the research design. However, from a strategic perspective, Creswell (2009:5) believes that a well-structured procedure can be used to intersect the adopted philosophy and strategy of enquiry to ensure that the research design is effective. Another view of ensuring the research design is effective is provided by Saunders, Lewis and Thornhill (2009:137-138) who recommend creating a clear set of objectives derived from the research questions to crucially reflect the selected structure. The research design should be planned carefully to yield results that are as objective as possible. Therefore, for the purpose of this study, the motivation for achieving these recommendations stems from answering the following two broad research questions:

- Will Lean produce superior business performance as a standalone improvement technique?
- Will Six Sigma produce superior business performance as a standalone improvement technique?

The aforementioned research questions are focused to empirically test and measure the scale of Lean and Six Sigma adoption as standalone systems in the sampled organisations accompanied by their associated strengths and weaknesses. The feedback to these questions will provide the means to deepen and enrich the critique for Lean and Six Sigma requirements compared to the literature in terms of the KZN context. This information was necessary to perform the first two constructs for the intervention of the Lean Six Sigma framework. Blumberg et al. (2005:32-33) assert that researchers should concentrate on the relationships that exist between the independent and dependent variables of a research study. It is anticipated that the independent variable generally causes the dependent variable to occur (Saunders et al., 2009:367). The dependent variable is a measured characteristic of the research problem where its value depends on the outcome of the independent variable. Furthermore, the independent variables are those factors that influence or affect the outcomes of a research project (Creswell, 2009:50; Sekaran, 2006:88). Therefore, the researcher usually tries to understand, describe or explain the variability that is prevalent within the dependent variable. The two broad categories of these questions are identified and modelled as the independent variables and the proposed business excellence derived in this study as the dependent variable. It is envisaged that the breakthrough in business excellence derived from the Lean and Six Sigma operating as standalone systems, can collectively be used to enhance the overall breakthrough in business excellence. Therefore, the classification of these variables will test the following hypothesis in this study:

H_0 - A relationship does exist between the integration of Lean and Six Sigma to achieve overall business excellence.

H_1 - A relationship does not exist between the integration of Lean and Six Sigma to achieve overall business excellence.

Based on the theoretical considerations presented above, this study follows the research design as demonstrated in Figure 8 to guide each step of this project.

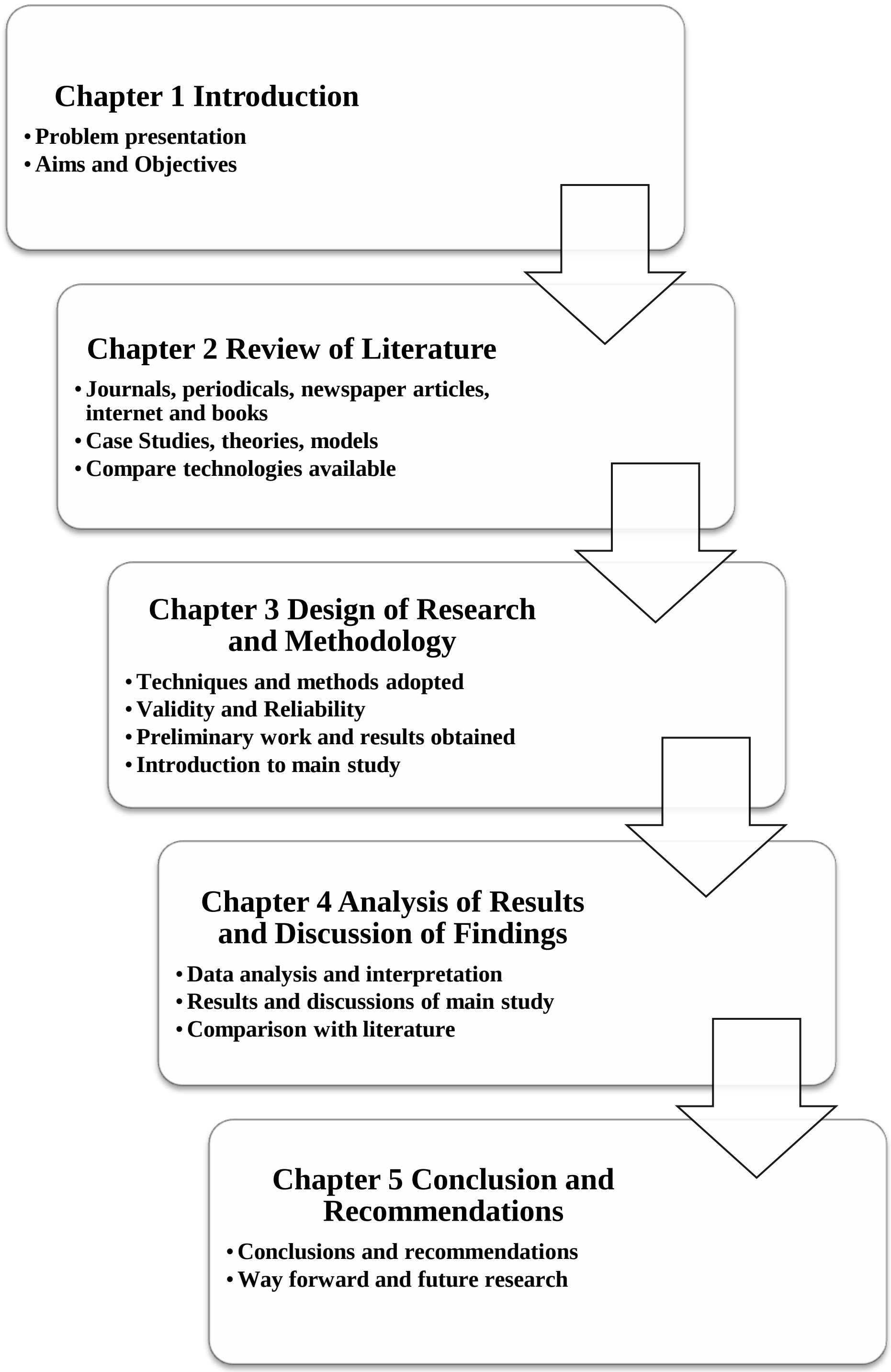


Figure 8 – Research Design

Figure 8 collates stepwise strategies to form the groundwork on which the design for this research study is based. The research starts by identifying the problem, followed by a detailed literature survey on the topic as similar studies have been done in other industries across the world (Psychogios, Atanasovski and Tsironis, 2012:124; Karthi et al. 2011:311; Snee, 2010:26;

Chen and Lyu, 2009:446; Thomas et al., 2009:114; De Koning et al. 2008:7). The objective of the literature search investigates the context of Lean, Six Sigma and Lean Six Sigma applications and analyses the success and failure cases of these techniques. Thereafter, the critical success factors required for the integrated Lean Six Sigma framework in terms of the KZN context are investigated. The results and discussions are provided in chapter 4 and the conclusions and recommendations are presented at the end of this study.

3.3 RESEARCH METHODOLOGY

Due to the different strategies that are commonly used in business and management research, Saunders et al. (2009:141) stipulate that a clear understanding of the research methodology is required to meet the objectives of a study. The selection of a specific strategy or the combination of strategies is dependent on the research questions and objectives set out in the study. Since the nature of a research study is identified and characterised by the level of knowledge the research topic has advanced, the methodology refers to the theoretical foundation of how a research project should be undertaken to accomplish the key objectives of the study (Saunders et al., 2009:3; Sekaran, 2006:119). On further examination, it has been identified that research methods generally consist of exploratory, descriptive and explanatory studies (Yin, 2009:7-8; Saunders et al., 2009:139-140; Terre Blanche et al., 2006:44).

An exploratory study is a valuable means of seeking new insights to a problem and assessing phenomena in a new light. It is preferred when there is little existing knowledge available within the area of study and the objective is to find fundamental understandings and formulate hypothesis of the area under investigation (Cooper and Schindler, 2006:143; Blumberg et al., 2005:146). Sekaran (2006:120) contends that exploratory studies can also be conducted when some facts are evident for an investigation area but more information is required for developing a viable theoretical framework. Hence, this type of study is particularly useful when clarity is required for understanding a problem and investigating new areas of research. The analysis of literature indicates that there is limited theory guiding the integration of the Lean and Six Sigma techniques into a compatible Lean Six Sigma framework. Attempts to integrate these techniques show that there is no valid or logical explanation to account for their compatibility (Thomas et al., 2009:113; Shah et al., 2008:6680; Bendell, 2006:255-259). In addition, the literature indicates that the integration of Lean and Six Sigma is still at an early stage in the business and academic field. This study involves extensive document research to authenticate the development of the key concepts on how Lean and Six Sigma can be integrated to form the Lean Six Sigma strategy to improve business performance. Thus, it made this part of the study exploratory in nature.

Descriptive studies, on the other hand, are typically structured and are undertaken to describe the characteristics of the variables of interest in a situation with clearly-stated hypotheses or investigative questions (Cooper and Schindler, 2006:151; Sekaran, 2006:121; Terre Blanche et al., 2006:44). It provides descriptions of phenomena or characteristics associated with a subject population by offering a profile of the factors. Although the objective of descriptive studies is used when basic knowledge exists within the research area and the study's objective is to describe phenomena under investigation, Blumberg et al. (2005:10) point out that a major discrepancy in this type of study is that it cannot explain why an event has occurred or why the variables interact in the way they do. This type of study generally portrays an accurate profile of persons, events or situations under investigation (Saunders et al., 2009:140). Since exploratory research entails investigating unknown areas of research, descriptive analysis was found to be most appropriate for collating all the key ingredients from the existing literature on Lean, Six Sigma and Lean Six Sigma implementations. This phase of the research based the investigation on similar studies that have been done in other industries across the world with studies from Corbette (2011:119), Delgado et al. (2010:518), Thomas et al. (2009:125-127), Chen and Lyu (2009:453) and De Koning et al. (2008:15-16). The information that was sought from the participants provided the evidence to describe Lean and Six Sigma techniques in the sampled organisations and contextually analysed the patterns of Lean Six Sigma applications identified in the literature by offering a profile of the factors. The selection of this method was motivated by the desire to uncover the preliminary evidence of the association among the various Lean and Six Sigma techniques.

Terre Blanche et al. (2006:44) maintain that studies which establish causal relationships between variables may be termed explanatory research. It is a type of study that examines a situation or a problem in order to explain the relationships that exist between the variables. An advantage is that it aims to proceed beyond describing a problem situation and attempts to explain the reasons for the phenomenon (Blumberg et al., 2005:10). This type of study uses theories or hypothesis to account for the forces that caused a certain phenomenon to occur. Explanatory studies are performed to describe and explain a research problem with the intention of increasing knowledge and creating a deeper understanding of the investigation area. Therefore, Cooper and Schindler

(2006:159) affirm that causal studies seek to discover the effect that one variable has on another variable or why certain outcomes are obtained. The concept of causality is grounded in the logic of hypothesis testing to produce inductive conclusions. The explanatory approach of this research was applied during the construction of the Lean Six Sigma framework. The activities and functions associated with Lean, Six Sigma and Lean Six Sigma are described in the literature and the desired information that was required in terms of the KZN context could only be obtained from participants within the sampled organisations. The information that was obtained from the participants, together with the literature review, was used to conduct the investigations and explain the application of theories that are related to the study. After the required level of knowledge and information was gathered, the appropriate calculations were performed to examine the relationship between the contextual factors and the extent of implementation of the various manufacturing practices that are key facets of Lean Six Sigma. This part of the study strived to consolidate and analyse the most appropriate techniques and strategies that would lead to a successful Lean Six Sigma deployment framework.

Prior to selecting a suitable approach to accomplish the objectives of the research undertaken, it is important to acknowledge the wide variety of research strategies that are available in literature. These are distinguished by experimental studies, survey methods, case studies, action research, grounded theory, ethnography investigation and archival research (Saunders et al., 2009:141; 587-601; Cooper and Schindler, 2006:705-718). Each of these strategies is commonly used to conduct exploratory, descriptive and explanatory research. The objectives of the different research strategies are classified as follows:

- Experiment study – A research strategy that involves the definition of a theoretical hypothesis, the selection of samples from a known population, and the control of the measured variables.
- Survey method – A research strategy that collects data from a sizeable population. Although it uses questionnaires, it includes techniques such as structured observations and interviews.
- Case study – A research strategy that investigates a phenomenon within its real life context.
- Grounded theory – A research strategy that develops theory from gathering data through observations and interviews.
- Action research – A research strategy that acknowledges the importance of change and involves collaboration between practitioners and researchers.

- Ethnography investigation – A research strategy that describes and interprets the social world through field study.
- Archival research – A research strategy that investigates administrative records and documents as the primary source of data.

Since each research strategy has its unique objective, as highlighted above, the most suitable research strategy for this study was sought. Upon considering the objectives and setting of this study, it was decided to select the action research strategy as it concentrates on the intervention of the real world and focuses close examination on the effects of the action that is investigated and this is consistent with Terre Blanche et al. (2006:557). In addition, Sekaran (2006:36) advises that action research is generally undertaken to substantiate change processes within organisations which, in this instance, is aligned with the objective of developing a Lean Six Sigma framework in terms of the KZN context. The selection of this research strategy is also supported by Cooper and Schindler (2006:217-218) who assert that action research is designed to address complex and practical problems about which little information is known and where researchers investigate the effects of the applied solutions. To add to another dimension on the strengths of action research, Saunders et al. (2009:587) assert that action research is a strategy concerned with the management of change and it involves close collaboration between practitioners and researchers. It is a research approach that can justify and propose changes in the business processes of organisations, which is the main objective of this study.

3.4 QUALITATIVE AND QUANTITATIVE TECHNIQUES

Apart from the discussions pertaining to the research design and methodological choices, there is also a differentiation that exists between qualitative and quantitative techniques which are commonly used to conduct research. Blumberg et al. (2005:125-126) advise that a qualitative or quantitative study depends entirely on the context of the research problem and objectives of the information that is required to answer the research questions. To maximise the effectiveness of either technique, Cooper and Schindler (2006:198) distinguish that qualitative techniques are commonly used to study phenomena that do not fit into particular theories from quantitative research that is often used for testing a theory and focuses on describing, explaining and predicting data with the use of statistical and mathematical methods.

The qualitative research approach focuses on exploring and understanding the meaning that individuals or groups ascribe to a problem (Creswell, 2009:4). The research process concentrates on emerging questions and procedures from which data is collected in the participant's setting. Qualitative studies base their accounts on qualitative information such as words and sentences that are concerned with verbal or pictorial descriptions (Cooper and Schindler, 2006:199; Blumberg et al., 2005:124). The data is analysed inductively by building from particulars to general themes and then making interpretations of the meaning of the data. It is implied that qualitative research is predominantly used as a synonym which allows the researcher to study the selected issues in depth as they identify and attempt to understand the categories of information that emerge from the data (Saunders et al., 2009:151; Terre Blanche et al., 2006:47).

The aim of quantitative research, on the other hand, is to test objective theories of a study by examining the relationship that exists among variables and to make broad and generalised comparisons between these variables (Creswell, 2009:4). These studies rely on quantitative information such as numbers and figures that are concerned with numerical codes (Blumberg et al., 2005:124). The connotations of these variables can be measured on instruments through the recording of numerical data and can be analysed statistically. Essentially, quantitative methods are predominantly used as a synonym for the data collection technique of a questionnaire or other data analysis procedures that includes graphs or statistics, which generates or uses numerical data as the measurement scale.

Having gained a better understanding of the difference between qualitative and quantitative techniques, it is evident that there are studies which combine both approaches. Although Cooper and Schindler (2006:219) refer to the combination of qualitative and quantitative techniques as triangulation, Saunders et al. (2009:152) and Creswell (2009:4) define this concept as a mixed method approach. Irrespective of the term given for this combination, the outcome is that it involves the use of both approaches in tandem so that the overall strength of a study becomes greater to enrich and improve the quality of the research. The combined approach assists the researcher to test the hypotheses more effectively and to confirm and support the empirical research results. Creswell (2009:14-15) recommends merging qualitative and quantitative data concurrently as it would allow the researcher to provide a comprehensive analysis of the research problem. Therefore, this study incorporated the combined approach such that it utilised the strengths of both qualitative and quantitative techniques. Through this method, the researcher collected both forms of data at the same time and then integrated the information in the interpretation of the overall results to enhance the research outcome. The combined approach is supported by Chakrabarty and Chuan (2009:618) who cite cases by Glaser and Strauss (1967) where the collection of different forms of data on the same subject generally assists in enhancing theory.

To effectively achieve the goals of understanding and interpreting theory, Blumberg et al. (2005:22) outline that a key consideration entails understanding the theory that is linked to inducing or deducing the different reasoning approaches when making conclusions. Cooper and Schindler (2006:708) define deduction as a form of reasoning approach where the conclusion is established from the given reasons. It is the process of interpreting the meaning of results that are obtained from the data analysis and arriving at conclusions. For the purpose of this study, deductive reasoning was used to determine if previously known success factors among the various Lean and Six Sigma techniques are also valid in a KZN business climate. Sekaran (2006:28) highlights that induction is the process of arriving at conclusions on the basis of observing a certain phenomena. Inductive reasoning draws conclusions from one or more pieces of evidence and the conclusion explains the facts of the situation. The process of inductive reasoning in this study was performed during the construction of the Lean Six Sigma framework.

3.5 DATA COLLECTION METHODS

Since data is the basic material with which researcher's work, it has been established that research involves collecting, analysing and interpreting data to make valid conclusions from an investigation (Terre Blanche et al., 2006:51). Blumberg et al. (2005:14) provide empirical support that good research generates dependable data which is compiled through practices that are conducted professionally and can be relied upon. In line with the traditional notions of research, data is normally obtained through primary and secondary data sources. Primary data refers to the collection of new information whereas secondary data is obtained by reviewing existing theory (David and Sutton, 2011:205). Saunders et al. (2009:280) explain that research projects are dependent on both primary and secondary data sources to answer the research questions and meet the study objectives.

The primary sources of data are obtained by researchers who seek firsthand information on the variables of interest for a specific purpose of the study (Sekaran, 2006:219). This type of data is in its original form and does not have any interpretation that represents an opinion. From an application point of view, Blumberg et al. (2005:69) establishes that primary data usually reflects the truthfulness of the investigation area due to the close collaboration that the researcher experiences with the phenomena. The availability of primary data is categorised by their qualitative and quantitative nature as highlighted by Creswell (2009:15) in Table 7. It is important to understand the difference between these two types of data since the appropriate method that will be used to answer the research questions is dependent on the type of data collected (Cooper and Schindler, 2006:77).

The secondary data sources are classified as interpretations that are derived from primary information (Blumberg et al., 2005:69). This type of data usually experiences at least one level of inference inserted between the event and its recording. Saunders et al. (2009:280) state that secondary data represents existing information which has been collected for other purposes and is available for building on theory. In terms of the secondary data obtained for the literature in this study, the initial step of the research was to systematically study and define the history of Lean, Six Sigma and Lean Six Sigma accompanied by its tools, techniques, strengths and weaknesses. This data was obtained through secondary sources that were selected from academic journals, relevant textbooks, periodicals, newspaper articles, encyclopedias and websites to build on the framework in the literature review as per Sekaran (2006:223). This is supported by Cooper and Schindler (2006:191) who assert that the exploratory phase of the research process uses secondary data to expand the understanding of the research problem and critique the methods that other researchers have addressed in the past to solve similar problems. The aim of secondary sources is to gather background information on the topic of concern and to refine the research question.

Quantitative Methods	**Qualitative Methods**	**Mixed Methods**
Pre-determined	Emerging methods	Both pre-determined and emerging methods
Instrument based questions	Open-ended questions	Both open and closed-ended questions
Performance data, attitude data, observation data, and census data	Interview data, observation data, document data, and audio-visual data	Multiple forms of data drawing on all possibilities
Statistical analysis	Text and image analysis	Statistical and text analysis
Statistical interpretation	Themes, patterns interpretation	Across databases interpretation

Table 7 – Qualitative, Quantitative and Mixed data collection methods (Adapted from Creswell, 2009:15)

The techniques that are commonly used to seek primary data evidence include experiments, surveys, archival analyses, histories and case studies (Yin, 2009:8). In concert with the survey stream of research, Sekaran (2006:223) asserts that interviewing, administering questionnaires and observing people are the three main data collection techniques. Upon studying Table 7, it can be inferred that a survey questionnaire can fit into the mixed methods approach for collecting both qualitative and quantitative data simultaneously in a study. This is possible through the use of both open-ended and close-ended questions and it focuses on multiple forms of data that draws on all possibilities to arrive at valid conclusions.

The choice of data collection methods such as mail questionnaires, telephone interviews or personal face to face interviews is important as it affects the quality of the data collected and it has cost implications. In particular Cooper and Schindler (2006:253) and Blumberg et al. (2005:249) acknowledge that questionnaires are very good for gathering factual information but they are less effective when sensitive and complex data are required. This is due to the interviewer not being able to intervene and clarify any misunderstanding that the participants may encounter. On the other hand, there are excessive costs associated with face to face or telephonic interviews as compared to administering questionnaires. Some of the advantages that survey questionnaires pose over other data collection techniques include: the effectiveness of the economy of the design and rapid turnaround in data collection, the questionnaires are completed at the participants convenience, there is no requirement for visual or other objective perception, the confidentiality of the participants are assured and there is an expanded geographic coverage without an increase in cost (Creswell, 2009:146).

The survey strategy with questionnaires can provide a description of the trends, attitudes, or opinions of a population after the data is collected and analysed statistically (Saunders et al., 2009:144; Creswell, 2009:145). This information can be used to suggest possible reasons for relationships that may exist between variables. Questionnaires are popular methods for gathering primary research data due to their flexibility and it can be custom designed to meet the objects of any research project as highlighted by Sekaran (2006:236). It is an efficient data collection mechanism when the researcher knows exactly what is required and how to measure the variables of interest. Essentially, a survey strategy enables more control over the research process and it is possible to generate findings that are representative of the entire population at a lower cost. Therefore, upon considering the advantages of the survey technique and based on the characteristics of the research question and the nature of the population to be investigated, it was decided to adopt the self administered questionnaire to obtain the primary data in this study.

3.6 QUESTIONNAIRE DESIGN

The construction of questionnaires is not an easy process as it requires special attention to detail regarding the information that needs to be collected to address the key objectives of the study (Cooper and Schindler, 2006:362-363). The selection of questions must consider the subject content, the wording of each question and the response strategy. Each question needs to be planned carefully and evaluated for its appropriateness to the study to ensure that the responses are valid in measuring what is required. In most cases, the questions selected must be examined within the context of which it is written instead of the entire abstract to ensure that it is not misinterpreted by the participants (Saunders et al., 2009:383). Sekaran (2006:240-241) and Terre Blanche et al. (2006:301) propose that the questionnaires should avoid the common wording errors such as double barrelled questions, ambiguous questions, leading questions, loaded questions, unfocused questions and positively and negatively worded questions.

Apart from the above, the questionnaire must share a common vocabulary that is easy to understand and interpret by the participants while providing adequate alternatives for their responses. The consequence of the participants misunderstanding or misinterpreting the questions could result in the researcher obtaining incorrect answers and the responses will be biased. To mitigate the possible effects of biasness, it has been observed that the questions asked, the language used and the clarity of the wording are the main determinants of a questionnaire that prompts the participants to provide honest opinions of their attitudes, perceptions and feelings when answering the questionnaire (Cooper and Schindler, 2006:365; Blumberg et al., 2005:468). This is supported by Saunders et al. (2009:366-367) who acknowledge that the questions need to be extensively reviewed for their appropriateness prior to data collection as the questionnaire usually offers a single chance to collect the required data.

There are two types of questioning techniques that are used for developing and constructing questionnaires, namely open-ended and close-ended type questions (Sekaran, 2006:239; Terre Blanche et al., 2006:486-487). Open-ended type questions are used when participants have to formulate their own opinion and responses in the questionnaire. Close-ended type questions, on the other hand, are generally used when participants do not have to express themselves verbally but rather make choices from a set of alternatives given by the researcher. It also helps the participants to make quick decisions and the results are easy to interpret since they are standardised and can be analysed statistically. This study adopted both open-ended and close-ended type questions in the survey type questionnaire design.

Terre Blanche et al. (2006:485) suggest that the questionnaire needs to be attractive, short and relevant to the research purpose to encourage the participants to answer all questions. Blumberg et al. (2005:265) contend that shorter questionnaires have the advantage of obtaining higher response rates. Furthermore, keeping both the visual appearance of the questionnaire and the wording of each question simple, serves as an effective means of obtaining valid responses. Another preparatory step includes filtering the questions and linking phrases accordingly to ensure that the questions appear logical to the participants. Cooper and Schindler (2006:363-364) state that questionnaires are commonly made up of administrative questions, classification questions and target questions that are structured to measure the participants views. The administrative questions generally seek to identify characteristics of the participant accompanied by the research location and conditions. Classification questions, on the other hand, usually cover sociological-demographic variables that allow the participants answers to be grouped into patterns for analysis purposes. Target questions address the investigative areas of a specific study and may be structured to include closed-ended type questions or unstructured, to incorporate open-ended type questions.

At the start of the questionnaire, it is important to explain clearly why the participant is required to complete the survey. In addition, the sequencing of questions ought to be structured such that the participant is led from questions of a general nature to those that are more specific and from questions that are relatively easy to answer to those that are progressively more difficult (Sekaran, 2006:242). At the end of questionnaire, it is recommended to thank the participant for their time and effort and highlight what needs to be done with the completed questionnaire (Saunders et al., 2009:389-391).

The responses that are obtained from attitude and opinion questionnaires of organisational practices generally provide a means of identifying and describing the variability that exists in different settings and enables the researcher to examine and explain the relationships that surface between these variables (Saunders et al., 2009:362). The questions that were formulated for this study incorporated a similar method to organisational practices in terms of the KZN context to elicit the variability that exists between the participants and to provide an account for the relationships that were established. In addition, all of the aforementioned points on questionnaire design were taken into consideration during each stage of the questionnaire construction for this study to try and avoid some of these cumbersome constraints and difficulties.

The questionnaire designed for the key variables of this study incorporated questions from literature that were closely linked with survey type questions developed by other researchers such as Pulakanam and Voges (2010: 158-161), Zu et al. (2008:645-648) and Shah and Ward (2007:803). In support of this method, Saunders et al. (2009:374) advise that questions used in other related questionnaires are more reliable and efficient than developing a new set of questions, provided it would collect the data that is required to answer the research questions and meet the study objectives. Although previously designed standard questionnaires were not used in this study, the gaps in knowledge which emerged from the literature above were used in the design of the questionnaire for this study. The choice of these studies show that the developed scales and questions had an accurate measure of validity and reliability and highlighted key variables that were required for Lean and Six Sigma techniques which were deemed to be justifiable in this study. The survey questionnaire in this study was developed to provide a baseline for Lean and Six Sigma techniques within the sampled organisations and to understand their existing quality management practices. All the essential characteristics in the questionnaire were generated by reviewing the existing literature and were embodied into five parts to collect the following information.

Section A queried fundamental issues such as information regarding the participants and the characteristics of the organisation. These included the profile of the organisation, the name and position of the participant completing the questionnaire, the number of years the participant has been employed in the organisation and the number of employees working in the organisation. This type of information would provide a certain level of confidence regarding the validity and reliability of the responses. For example, if a participant has been employed in an organisation for more than five years, it is perceived that they would have sufficient knowledge of all the key processes and procedures within the organisation. The data obtained in section A was used to categorise the sampled organisations within the automotive sector for analysis purposes.

Section B contained questions pertaining to organisations that practice the Lean technique. The questions were set out to examine the current strengths and weaknesses of the Lean technique from a KZN perspective. This section incorporated both open-ended and close-ended type questions.

Section C encompassed questions pertaining to the organisations that practice the Six Sigma technique. The questions were set out to examine the current strengths and weaknesses of the Six Sigma technique from a KZN perspective. This section incorporated both open-ended and close-ended type questions.

Section D consisted of fifty four variables associated with the Lean Six Sigma technique that were extracted from the literature review. The questions were grouped into seven categories that represented the critical success factors of Lean Six Sigma. These categories included organisational infrastructure, management commitment and leadership, commitment to quality, production control, process improvement, employee involvement and customer focus. Close-ended type questions were incorporated in this section and the participants were required to rate each statement that was most applicable to their organisation.

Section E comprised of a list of quality improvement tools and techniques that are used in Lean and Six Sigma organisations. The participants were required to make their selection from this list of quality improvement tools and techniques that are commonly used in their organisations.

The questionnaire was objectively phrased with simple terminology and clear explanations were provided to ensure that the participants understood and interpreted the questions correctly when providing their responses. As a method of keeping the participants focused throughout the completion of the questionnaire, the survey started with simple questions of a general nature and then progressed to lengthier questions of a specific nature. With the purpose of stimulating the sampled organisations to answer the questionnaire, a covering letter accompanied the questionnaire and provided an overview of the challenges facing South African businesses and the objectives of this study. Saunders et al. (2009:389) confirm that a covering letter is intended to explain the purpose of the survey and it is the first part of the questionnaire that a participant views. In the instruction section, clear guidelines were presented on the requirements of the questionnaire, the timing and the assurance of anonymity and confidentiality. The last part of the covering letter informed the participants that they could receive a copy of this study if so desired.

3.7 MEASURING INSTRUMENT AND SCALE

A measurement scale is a tool that is used to distinguish how individuals or other phenomena differentiate from each other based on the variables of interest in a study (Sekaran, 2006:185). Cooper and Schindler (2006:309-316) propose that measurement in research includes selecting the empirical events of the study, followed by developing mapping rules to assign numbers or other variables which represent what is being measured and finally applying the mapping rules to each event that is measured. The combination of classification, order, distance and origin provides the four common types of measurement scales that are referred to as nominal, ordinal, interval and ratio. Each scale has a distinct purpose and objective for categorising data as follows (Sekaran, 2006:185-189; Terre Blanche et al., 2006:155-156):

- Nominal scale - Determines the equality of data and classifies information such as creating a profile of the participants by using a frequency distribution. Although this scale indicates that there is a difference between the categories of objects, persons, or characteristics, it does not indicate the order of the information
- Ordinal scale – Indicates categories of variables that are both different from each other and ranked in terms of an attribute
- Interval scale – Uses attitudinal scale rankings to determine the equality of intervals and the magnitude of differences on the data collected
- Ratio scale – Measures physical dimensions of characteristics and represents the actual amount of a variable. It is used to determine the equality of ratios and possess all the features of the other three scales as there is a fixed and absolute zero point

Blumberg et al. (2005:417) attest that measurement scales are commonly incorporated into the measuring instrument of a study to represent numbers or other variables that measure the opinions, attitudes and other concepts from a population. The two common approaches that are used for obtaining data through measurement scales include rating scales that provide several response categories of the variables being studied and ranking scales that make comparisons between variables to elicit the preferred choices and ranking among them (Sekaran, 2006:196). Classifying variables according to their level or scale of measurement is necessary to facilitate the choice of a statistical test to analyse the data.

Some of the common rating scales identified in literature include dichotomous scale, category scale, Likert scale, numerical scale, semantic differential scale, itemised rating scale, staple scale, graphic rating scale, and consensus scale. Cooper and Schindler (2006:339) posit that the Likert scale is the most popular rating scale due to its ease of construction and reliability and it provides a greater volume of data in comparison to the other scales. The Likert scale is a summated rating scale which is used to gain the opinion of participants by using interval data. In this type of scale measurement, the participants are required to express either a favourable or unfavourable attitude towards the object of interest. Each response is given a numerical score to reflect its degree of attitudinal favourableness, and the scores may be added to measure the participant's attitude. Sharing similar views as Blumberg et al. (2005:395), Saunders et al. (2009:378) accentuate that the Likert style rating commonly measures responses on an even or odd number range. The odd number of points on the rating scale allows the participant to select the middle category "not sure" when considering an implicitly negative statement. It is used as a strategy to appear less threatening to the participant instead of them admitting they do not know and cannot provide a valid response.

The selection and construction of a measurement scale needs to take into account the research objectives, the type of responses that are required, the data properties that will be used for analyses, the number of dimensions that are used to describe an event and the number of scale points to rank an event (Cooper and Schindler, 2006:332-333). All of these prescribed points were taken into account during the development phase of the measuring instrument in this study to ensure relevant data was collected from the sampled organisations. Considering the objectives of nominal scale ratings, it can be inferred that the first part of the questionnaire (Section A) made use of the nominal scale to provide a profile of the organisations used in this study. Sections B and C were developed with both qualitative and quantitative questions and therefore the responses could be not be scaled as they were subjective and required summarising and categorising the data for analysis. Section D incorporated an ordinal scale to gather interval data by measuring the extent of quality and process improvement practices in the selected organisations as classified by Lean Six Sigma success factors. The participants were required to rate each statement on a 5 point Likert scale to the extent of which they "Do Not Agree At All" (1) to "Agree Fully" (5) with the statements provided. The last section (Section E) of the questionnaire was developed with nominal data and the participants were required to rank the common tools that were deployed in their respective organisations.

3.8 VALIDITY, RELIABILITY AND PRACTICALITY

The credibility of a study depends on the characteristics of the measuring instrument and the nature of the data collected. Since these are important facets of any research method, Cooper and Schindler (2006:318) and Blumberg et al. (2005:378) postulate that the validity, reliability and practicality of the measuring instrument are the three metrics that can reveal the study's credibility. These are tests that are commonly performed on the measuring instrument to establish the quality of the research and to ensure that the data obtained is a true reflection of what is being measured and investigated (Yin, 2009:40).

3.8.1 VALIDITY

The validity of a questionnaire design reveals the degree to which an instrument measures the concept that it is intended to measure and to assist the researcher in solving the research problem (Saunders et al., 2009:157). Terre Blanche et al. (2006:147) and Sekaran (2006:206) are in agreement that the validity of a questionnaire confirms if a test accomplishes what the researcher sets out to verify and that the differences identified in the measurement tool reflects the true differences between the participants. If a measuring instrument has a high validity construct it implies that the measuring instrument would achieve the desired outcomes of the research findings with a high level of confidence. In most cases, the internal and external threats of validity are commonly investigated to conclude if the intervention variable affects an outcome of the research findings as opposed to any other factor (Creswell, 2009:162). The external validity defines the domain to which a study's findings can be generalised (Yin, 2009:40). As a result, the external validity threats arise when studies draw incorrect inferences from the sample data and are generalised across people, settings and times.

The internal validity refers to the confidence that the cause and effect relationship encounters through the ability of a research instrument to measure what it is designed to measure and the extent to which causal conclusions can be drawn (Saunders et al., 2009:372; Sekaran, 2006:149; Terre Blanche et al., 2006:90). Internal validity threats include experimental procedures or experiences of participants that threaten a researcher's ability to draw correct inferences from the data about the population in an experiment. Therefore, the internal validity check for the investigation assists the researcher in arriving at the correct conclusions according to the research questions that are asked.

The internal validity review of this study ensured that the questions were clearly understandable to the participants as it was directly linked to their daily operational functions and aligned to Lean Six Sigma. This approach was used as a strategy to arrive at the correct conclusions according to the research questions asked and to maintain high construct validity. Since the covering letter of the questionnaire explained the benefits of the research, it was anticipated that the participants would answer the questions honestly. The external validity verification entailed working closely with other similar studies identified in literature to generalise and compare the findings from a KZN perspective (Psychogios et al. 2012:124; Karthi et al. 2011:311; Snee, 2010:26; Chen and Lyu, 2009:446; Thomas et al., 2009:114; De Koning et al. 2008:7). Apart from the internal and external threats to validity, there are content validity, criterion-related validity and construct validity tests that are performed by researchers to ensure that the questionnaire design is valid for its intended purpose (Cooper and Schindler, 2006:318; Blumberg et al., 2005:380). These validity tests are classified as follows:

- Content validity - the extent to which the measuring instrument provides adequate coverage of the investigative questions guiding the study (Saunders et al., 2009:373; Sekaran, 2006:206; Terre Blanche et al., 2006:149). It is a type of theoretical check to ensure that the measuring instrument includes a sufficient and representative set of items that draw on the concept of the area being investigated. To evaluate the content validity of an instrument, it is important to understand which elements provide an adequate reflection of the topic under study. If the instrument contains a representative sample of the population of the subject matter of interest, then it is perceived that the content validity is good. The literature review can assist in verifying if the content validity of the measuring instrument is good in the context of the investigation area.
- Criterion-related validity - refers to the ability of a measuring instrument to predict an outcome or estimate the existence of a current condition. Sekaran (2006:416) acknowledges that criterion-related validity is established when the measure differentiates individuals on a criterion that it is expected to predict. This form of validity check is established by comparing the measurement tool with another measure of the same construct (Terre Blanche et al., 2006:147). An example is when a researcher undertakes the empirical task of determining whether a new research measurement tool relates to previous measures in a similar investigation area. The criterion-related validity can be established by testing the measure to differentiate individuals who are known to be different (Sekaran, 2006:308).

- Construct validity - The construct validity refers to the extent of how well the results of the measuring instrument fit the theories around which the test is designed (Saunders et al., 2009:373; Sekaran, 2006:207). In application, Creswell (2009:164) claims that the threats to construct validity occur when investigators use inadequate definitions and measures of variables. Therefore, Yin (2009:41) advises that the construct validity should identify correct operational measures for the concepts that are being studied. A proper evaluation of the measuring instrument compared to the theory of the subject content can assist the researcher in verifying construct validity.

For the purpose of this study, the literature review process guided the formulation of the questions to provide adequate coverage of the research topic to improve the content validity. Yin (2009:41) advises that the use of multiple sources of data is a tactic that is also employed to achieve high construct validity. The consequential result of selecting the mixed methods approach strategy assisted in avoiding single source biasness. Terre Blanche et al. (2006:163) advise that if a study possesses significant validity checks, then its findings would follow in a direct and unproblematic sequence from its methods and in addition sustain its findings and conclusions. Therefore, owing to all the aforementioned validity checks highlighted above and those performed in this study, it is anticipated that this research would produce a high degree of validity.

3.8.2 RELIABILIY

Saunders et al. (2009:373) mention that in order for a questionnaire to be classified valid for a research study, it should be reliable. The reliability of a study's measuring instrument refers to its ability to produce consistent results when the study is repeated. The purpose of good reliability is to investigate the accuracy and precision of the measurement procedure and minimise the errors and biases in the study (Yin, 2009:45). This means that if a later researcher follows the procedures as described by an earlier researcher to conduct the same study again, the later researcher should arrive at similar findings and conclusions. The common reliability checks entail testing and retesting of the measuring instrument, verifying internal consistency of the participants and utilising parallel forms to ensure that alternate forms of the measure yield similar results (Cooper and Schindler, 2006:321).

A key construct in maintaining the reliability of a study is to document all procedures that are followed in the research process to assist in repeating a similar study. In essence, the reliability of a measuring instrument is an indication of the stability and consistency with which the instrument measures the concept under investigation and helps to assess the effectiveness of the measure (Sekaran, 2006:203). Sekaran (2006:307) claims that Cronbach's Alpha reliability analysis is commonly used to test the internal consistency of the measurement scale and it indicates how well the questions measure the concept. Thus, achieving a Cronbach's Alpha value close to 1 indicates high reliability. The Cronbach's Coefficient Alpha test was used to verify the reliability of the data collected in this study.

3.8.3 PRACTICALITY

The scientific grounding of a project verifies if the measurement process is reliable and valid while the operational requirements, on the other hand, acknowledges if the measuring instrument is practical (Cooper and Schindler, 2006:323-324). The practicality of the measuring instrument implies that it should be economical, convenient and interpretable. The economical factors relate to the research budget and the cost implications that surfaces when collecting data through interviews, telephone surveys and standardised tests. These data collection methods are expensive and require sufficient funds to achieve the desired outcomes of the project. The convenience of the measuring instrument is reflected by the layout of the questionnaire, the instructions provided and the administration of the questionnaire. All of these items influence the participant's feedback. The aspect of interpretability implies that the results from the study should be clear, understandable and easy to interpret by anyone other than the researcher. Therefore, the researcher should provide an explanation of how the test was designed to measure the variables of the study in order to make interpretation as easy as possible.

The practicality of the measuring instrument in this study was pilot tested and reviewed by academics and practitioners to determine if the questions and statements were adequate to elicit the development of a Lean Six Sigma framework. The survey was conducted through electronic mail which resulted in a reduction of cost implications. In addition, a statistician assisted with the analysis and interpretation of the results to make it clearly understandable.

3.9 PILOT TEST

In order to succinctly obtain valid and reliable data to answer the research questions and meet the objectives of a study, Saunders et al. (2009:394), Cooper and Schindler (2006:76) and Blumberg et al. (2005:68) are in agreement that the measuring instrument should be rigorously tested to identify possible weaknesses in the design and instrumentation prior to conducting the main study. The preliminary analysis of the pilot test data serves as the verification method to ensure that the data collected will answer the main investigative questions. Therefore, the pilot test seeks to refine the measuring instrument such that the participants do not experience difficulty in answering the research questions and that there are no additional problems encountered during the recording of the data. Furthermore, the pilot test represents an indication of the questions validity and reliability.

The pilot study is the pre-testing phase of a research process that involves the use of a small number of participants to test the appropriateness of the questions and their comprehension (Sekaran, 2006:249; Terre Blanche et al., 2006:94). The objective of pilot work is to identify ambiguity and other related problems that are commonly encountered with wording or measurements in a questionnaire. Blumberg et al. (2005:69) advise that pilot work may be repeated several times in order to provide significant insight and ideas for refining the questions, instruments or procedures of the research design to ensure that the objectives of the study are achieved.

Babbie and Mouton (2001:244) are of the opinion that studies usually undertaken in South Africa neglects the pilot work phase of the questionnaire construction. Pilot work is important especially where more than one cultural group is included in the study. Therefore, the initial draft questionnaire developed for this study was reviewed by Lean and Six Sigma experts, academics and members of the DAC executive team to verify the validity of the questionnaire to the KZN context. The evaluation of the questionnaire was used as a strategy to verify the formulation, order and content of the questions adopted in terms of its relevance to the research topic and the suitability for organisations. After gaining academic and ethical approval for the questionnaire design and content, preliminary work in the form of a pilot test was conducted to establish the feasibility, comprehensibility and accuracy of the questionnaire in the practical environment. The pilot study was used as a measure to determine if the participants encountered any problems in answering the questionnaire and to establish if the methodology adopted would meet the objectives of this project. The pilot questionnaire was administered to senior management at 5 organisations within the DAC. Gaining feedback from the pilot study enabled the researcher to further revise the questionnaire and to ensure that it was sustainable for the main study. It allowed a thorough checking of the questioning process and assisted in removing ambiguities and improving the questions and wording.

3.9.1 QUESTIONNAIRE PRE-INTERVENTION

During the "pre-intervention" stage of the questionnaire administration process, the participants selected were given a courtesy call and advised that this was the pilot work phase of the research project. The participants were requested to provide feedback on the timeframe allocated to complete the questionnaire and if the questions and statements were easy to understand and interpret. In addition, they were encouraged to give their views regarding further topics that could be investigated through the questionnaire. The pilot questionnaires were distributed via e-mail to the respective participants and the participants were allocated two weeks to return the completed questionnaire.

The researcher decided to call the participants after receiving their feedback as a follow up strategy to get a general overview of their outlook regarding the questionnaire. This method allowed the researcher to address the following issues as proposed by Saunders et al. (2009:394):

- How long the questionnaire took to complete
- The clarity of instructions
- If any questions were unclear or ambiguous
- If any questions the participant felt uneasy about answering
- Whether in their opinion there were any major topic omissions
- Whether the layout was clear and attractive
- Any other comments

The feedback regarding the concerns above and the recommendations stemming from the "pre-intervention" of the pilot test are discussed in the next section. The pilot test data acts as the catalyst to verify if the feedback received will address the research questions appropriately (Cooper and Schindler 2006:76). The validity stance adopted in this study is highlighted in section 3.8.1. The statistical analysis of the pilot test data assisted in understanding and interpreting the results obtained through the questionnaire. The Statistical Package for Social Science (SPSS) software was used to categorise, analyse and interpret the data.

3.9.2 QUESTIONNAIRE POST-INTERVENTION

The pilot questionnaire can be viewed in appendix A. The detailed findings of the pilot study are presented below.

The feedback and additional contributions obtained from the participants in the industry were taken into account to improve the operational and practical requirements of the main questionnaire. Although there were significant criticisms directed to the pilot questionnaire, the positive feedback indicated that the organisations were keen to participate in this survey. The questionnaire was divided into five sections and shortcomings were identified in sections B, C and D. The participants highlighted that some of the terminology used in section D was difficult to interpret and certain statements were not clear. Another suggestion was to increase the demarcated space that was provided to answer the qualitative questions in section B and C. The participants also noted that the questionnaire was taking an average of 35 minutes to complete although the instruction indicated that it would not last longer than 25 minutes. Therefore, the timeframe was increased from 25 minutes to 45 minutes allowing the participants sufficient time to complete the questionnaire in the main study.

The statistical technique applied to section D of the pilot study questionnaire included Cronbach's Alpha reliability test. It was found that the Cronbach's Alpha value for the total set of 54 questions in section D was 0.877. This value indicated that the overall reliability score was very good for the present study.

Based on the results of the pilot work and the feedback received by the researcher from the pilot sample participants, the questions were edited accordingly to enable the extraction of valid and reliable data. The results from the Cronbach's Alpha reliability analysis indicated that 3 questions were strongly negative and 5 questions were incorrectly answered or could have probably been misinterpreted in section D. In addition, one question in section B and one question in section C were identified as inappropriate and could be eliminated respectively. Thus, the questions which were negative and incorrectly answered in section D were modified with the assistance of the research supervisor to facilitate the comprehension. The inappropriate questions from section B and C were eliminated.

In terms of findings related to specific tools, of the five organisations included in the pilot study, two organisations practiced Lean and Six Sigma as standalone techniques, one organisation practiced Lean "only" and two organisations practiced neither technique. Consequently, the pilot study cannot report on results for organisations practicing Six Sigma "only" as a technique.

At the time of gathering these findings, it was not considered that none of the organisations which formed the sample of the main study, practiced Six Sigma "only" as a standalone system. Hence no organisations in the main study were considered in terms of practicing Six Sigma "only". At this stage of this research and for it to be representative of the actual behaviour of the DAC, it was deemed that the main study continue with organisations practicing Lean and Six Sigma as standalone systems, as it would be reflective of the practice within the DAC. This is discussed in detail in section 4.4.

There were no logistical problems experienced with the administration of the questionnaire via the e-mail process. Following the editing process of the pilot questionnaire, the main study questionnaire was verified by academics to confirm that the measurement scale captured the construct that it was intended to measure. Through this approach and from a methodological standpoint, the corrections thus made hoped to enhance the accuracy of the results. The final research gathering questionnaire can be reviewed in Appendix B.

The main study followed a similar format as the pilot study; however, the questionnaires were administered to all organisations within the DAC and they were given an opportunity of three months to complete the questionnaire. The contact details for the organisations sampled were obtained from the DAC website. Prior to sending out the questionnaires, the organisations were contacted by the DAC representative to make them aware of the research undertaking. The main study survey began on the 03 December 2012 and the due date for completion was given as 04 March 2013. The majority of the participants returned the completed questionnaire within the first month. There was a 75% response rate at the end of the three month period which indicated that this was large enough to draw valid conclusions with a fairly high level of confidence. The completed questionnaires were verified to establish whether all questions were answered before they were used for analysis. There was no need for any follow up or clarification with the participants as all the questionnaires appeared to be correctly completed.

3.10 TARGET POPULATION AND SAMPLE SIZE

The target population of a study usually represents the entire collection of subjects or elements from which data is collected to make inferences of the area under investigation (Cooper and Schindler, 2006:402-403). David and Sutton (2011:227) and Saunders et al. (2009:212) advise that a census represents the total population group from which data is gathered to answer the research questions. In such cases, a census is conducted if the entire target population group is of a manageable size. However, in some cases the target population may be too large to obtain the required data for a study and therefore sampling may be necessary as a valid alternative to a census (Terre Blanche et al., 2006:133). Sampling is the process of selecting a sufficient number of elements from a target population to provide the required information in a study. The advantages of using sampling instead of surveying the entire population includes lower cost, greater speed of data collection and the availability of the population elements. The two basic types of sampling techniques available are probability sampling that includes all members of the population and non-probability sampling which includes a representative sample from a population (Sekaran, 2006:269).

Non-probability sampling includes convenience, purposive and snowball sampling procedures as opposed to the statistical principal of randomness in probability sampling. Convenience sampling entails selecting units from the population that is easy available or accessible while purposive sampling on the other hand allows researchers to rely on their experience, ingenuity or previous research findings to collect information from sample members that is representative of the relevant population. Snowball sampling is performed by approaching a few individuals from a population after which these individuals acts as informants and identifies other members from the same population for inclusion in the sample (Saunders et al., 2009:237-241).

Saunders et al. (2009:243) provide empirical support that the choice of sampling is dependent on the feasibility and sensibility of collecting data from the entire population. In this regard, they recommend performing a census for a population group below fifty. In addition, a census is feasible when the population group is small and the elements are different from each other (Cooper and Schindler, 2006:404; Blumberg et al., 2005:205). Generally, the size of the population dictates if a sample is required or a census is feasible. Therefore, for the purpose of this study, a census was conducted since it involved the choice of all participants and because the population size was smaller than fifty.

This study was conducted in KZN, which is home to a significant portion of the automotive industry in South Africa. Toyota South Africa, the largest vehicle manufacturer in the country, is located in the province, as are several national and international automotive component manufacturing organisations. Twenty five percent of all light vehicles manufactured in South Africa are produced in KZN (http://www.kzntopbusiness.co.za/site/top-business-sector/Durban-Automobile-Cluster, 2013). The DAC member organisations consist of more than 90% of all automotive manufacturing activity in KZN. Therefore, the study was confined to the greater Durban region in KZN; hence, organisations within the DAC formed the population for this project. The target population in this study can be considered to represent majority of the automotive component manufactures in KZN only. Although other provinces in South Africa were not considered for this study, the high volume of automotive manufacturing activity in KZN strengthens the study to represent a significant portion of the automotive industry in South Africa.

According to the sample size determinator from the Stat Graphics statistical package software, a 95% level of confidence indicates an appropriate sample size of thirty (Singh, 2011:1622). It is also highlighted in literature that statistical analyses usually require a minimum sample size of thirty elements for investigation (Saunders et al., 2009:243). There were forty two organisations within the DAC at the time of conducting the survey; however, only thirty two participants completed the questionnaires. This was sufficient to adopt certain statistical analysis techniques and validate conclusions from the findings.

Since this survey assessed practical experience and knowledge instead of general perceptions, the target participants included Operations Managers, Quality Managers, Production System Managers, Six Sigma Experts and Lean Specialists who were knowledgeable and familiar with the terminology. In addition, the selected participants were directly involved in the process and were expected to have first-hand knowledge and experience of their quality and process improvement techniques. Owing to the unique selection of the high profile participants and their familiarity with their processes, it was anticipated that the feedback received would be reliable. It should be emphasised that this study was confined to the members of the DAC only; therefore, it restricts the researcher to make any inferences to other automotive component manufacturing organisations in South Africa.

3.11 DATA ANALYSIS

It is not practical to present raw data in a research report as it would be difficult to interpret and manage for the study. Therefore, the objective of data analysis is to reduce the accumulated data to a manageable size, develop summaries of the data, look for patterns, and apply statistical techniques in order for researchers to specify the conditions under which their conclusions are valid. The intentions are to get a feel for the data, test the goodness of the data and verify the hypotheses developed for the research (Sekaran, 2006:306; Cooper and Schindler, 2006:77; Blumberg et al., 2005:69-70). The type of statistical procedure that a researcher employs in analysing data depends on the purpose of the study and the type of data the researcher has collected (Terre Blanche et al., 2006:212). The methods that were employed for analysing the data collected in this study included descriptive statistics such as frequencies, means and gap values and inferential statistics such as factor analysis, communalities and hypotheses testing. In addition, qualitative analyses were performed for the open-ended type questions in sections B and C of the questionnaire.

3.11.1 DATA EDITING, CAPTURING AND PROCESSING

The completed questionnaires were examined by the researcher for errors and verified by the supervisor before the data was extracted for analysis. A coding system was used to capture the raw data from the questionnaires into electronic format on an Excel spreadsheet. The dichotomous close-ended type questions were represented by “Y” for Yes and “N” for No. In addition, the 5 point Likert scale were given numerical values of 1 to 5 to represent the responses of “Strongly Disagree” (1), “Disagree” (2), “Neutral” (3), “Agree” (4) and “Strongly Agree” (5). The statistician verified the coding and accuracy of the data input before performing the statistical analysis. In the case of open-ended type questions, content analysis was used to categorise the responses based on thematic units. The data was categorised into a format that could be used to derive recommendations in a structured format. This method allowed the researcher to present the various themes extracted from the data in order of importance (Saunders et al., 2009:536).

3.11.2 DESCRIPTIVE STATISTICS

The objective of descriptive statistics is to transform raw data into a form that provides information to describe a set of factors in a situation. Researchers generally use descriptive statistics to describe and compare variables numerically through the ordering and manipulation of the raw data collected (Saunders et al., 2009:444, Sekaran, 2006:394-395). It describes the data by investigating the distribution of the scores on each variable and by determining whether the scores on the different variables are related to each other (Terre Blanche et al., 2006:558). The analysis is tabulated in the form of frequency graphs, mean scores, gaps, standard deviations and measures of central tendency (Creswell, 2009:166; Sekaran, 2006:416). For the purpose of this study, means scores, gaps and frequencies were used to evaluate the data from sections B, C and D of the questionnaire and are presented as tables and figures in chapter 4. The gap values represented the difference between the actual mean score and the hypothesized perfect score of 5.

3.11.3 INFERENTIAL STATISTICS

The objective of inferential statistics is to enable the researcher to explain how the different variables in a study relate to each another. It establishes relationships that exists between the different variables and draws conclusions about the population through the sample data (Terre Blanche et al., 2006:560; Sekaran, 2006:418). Creswell (2009:166) states that this type of statistical analysis is conducted to examine the hypothesis in the study. Some of the inferential statistical calculations performed on the data for this study included Kruskal Wallis tests, Kolmogorov-Smirnov test of Normality and Pearson’s Chi square test. The Pearson’s Chi square test was selected to test the nature of the distribution as the researcher was primarily interested in determining the nature of the spread of the scoring patterns within each variable. The results for the Kruskal Wallis test and Kolmogorov-Smirnov test of Normality can be viewed in Appendix D and E respectively.

The factor analysis statistical technique is commonly used to identify a portion of the factors that represent the relationship among a set of interrelated variables. This is accomplished by computing the inter-correlations between the variables, extracting the initial factors and then rotating the factors to obtain a clear picture of the factor content (Terre Blanche et al., 2006:248). The aim of factor extraction is to transform the original set of variables into a new set of noncorrelated variables called factors that belong together and have overlapping measurement characteristics (Cooper and Schindler, 2006:590). A typical use of factor analysis, according to Gaur and Gaur (2009:131-132) and Pallant (2005:172), occurs in survey research where a researcher wishes to represent a number of questions with a small number of hypothetical factors. The result of the factor analysis conducted in this research is presented in a rotated component matrix which can be viewed in Appendix C. Certain components are divided into finer components. With reference to the factor analysis table in Appendix C:

- The principle component analysis was used as the extraction method and the rotation method was Varimax with Kaiser Normalization. This is an orthogonal rotation method which minimises the number of variables that have high loadings on each factor. It simplifies the interpretation of the factors.
- Factor analysis/loading show inter-correlations between variables.

An examination of the content of items loading at or above 0.5 measured effectively along the components of sections B, C, D1, D2 and D3, respectively. This means that the questions (variables) which constituted the components loaded into one factor and perfectly measured the component. However, all of the other components (sections D4, D5, D6 and D7) have factors that overlap, indicating a mixing of the factors. This means that the questions in the overlapping components did not specifically measure what it set out to measure. This could be with respect to interpretation or inability to distinguish what the questions were measuring.

The communality for a given variable, according to Gaur and Gaur (2009:133) and Kinnear and Gray (2009:568), can be interpreted as the total proportion of its variation that is accounted by the extracted factors. An assessment of how well the questionnaire model is doing can be obtained from the communalities. The ideal, according to Kinnear and Gray (2009:573), is to obtain values that are close to 1. This would indicate that the questionnaire model explains most of the variation for those variables. In the case of this study, the questionnaire model is acceptable as it explains approximately 80% of the variation for the 4 variables in section B, 90% of the variation for the 4 variables in section C and 70% of the variation for the 54 variables in section D. The individual communalities and average scores of the components are discussed in the results (chapter 4).

3.11.4 HYPOTHESIS TESTING

A hypothesis is a logical conjectured relationship between two or more variables expressed in the form of a testable statement (Sekaran, 2006:103). It is used to explain the nature of certain relationships between variables or the independence of two or more factors in a situation (Sekaran, 2006:124; Terre Blanche et al., 2006:560). The role of hypothesis testing is to guide the direction of the study and to distinguish those facts that are relevant from those that are not. It suggests which form of research design is most appropriate for the study and it provides a framework for organising the conclusions that surface. Therefore, a strong hypothesis needs to be adequate for its intended purpose and be better than the alternative hypothesis (Cooper and Schindler, 2006:45; Blumberg et al., 2005:38).

The hypotheses are generally evaluated by determining if the statistical likelihood of the data reveals true differences instead of random sampling error. The importance of statistically significant differences is evaluated by weighing the practical significance of any change that is measured. Therefore, it is implied that a difference has statistical significance only if there is a good reason to believe that the difference does not represent random sampling fluctuations (Cooper and Schindler, 2006:492). The null hypothesis is used for testing and it is a proposition that states a definitive and exact relationship exists between two variables. The alternative hypothesis is the logical opposite of the null hypothesis and is a statement expressing a relationship between two variables or indicating differences between groups (Sekaran, 2006:105; Cooper and Schindler, 2006:494). The Pearson's Chi square test was performed to determine whether there were statistically significant relationships between the variables in this study. As suggested by Kinnear and Gray (2009:409) and Pallant (2005:290), a p-value is generated from a test statistic with a significant result indicated by "$p < 0.05$". All significant Chi Square values are highlighted and discussed in chapter 4.

3.11.5 QUALITATIVE ANALYSIS

The essence of qualitative data is to provide a description of the subject under study through the use of interpretive techniques such as decoding and translating the data, deciphering patterns that surface, and discovering the meaning of phenomena that occur (Sekaran, 2006:409). In application, Saunders et al. (2009:516) propose that qualitative data should be summarised, categorised and structured for analysis. In addition, the interpretation of qualitative data can be performed through familiarisation and immersion, inducing themes, coding, elaboration and interpretation. Coding entails marking different sections of the data relevant to one or more of the themes (Terre Blanche et al., 2006:322-326). This data reduction approach leads to the identification of core categories within the qualitative data and to the build up of a logical chain of evidence which is an important precursor to the data analysis. Where possible, the data is coded and a table is generated by associating the data to the different categories. After patterns emerge, the content analyses of the data are used to understand the characteristics of the measurement. This study used the method of summarising and categorising the qualitative data obtained from the survey, which is presented in the next chapter.

3.12 SUMMARY OF THE CHAPTER

This chapter outlined the systematic approach of the research design adopted to accomplish the key objectives of the empirical study. A combination of exploratory, descriptive and explanatory research methods was applied to different sections of the project to gather the necessary data to answer the research questions. The research methodology included a combination of both qualitative and quantitative data gathering techniques using the survey method. The importance of sampling and the target population; and the choice of selecting the appropriate measuring scale and instrument were also defined. A questionnaire served as the main data gathering instrument and was validated prior to the main study. The pilot study highlighted the important aspects of the questionnaire design and detailed how the research addresses the validity, reliability and practicality. The main objective of the questionnaire was to elicit current Lean and Six Sigma practices in the sampled organisations within the DAC. The five participants who were selected from the target population to participate in the pilot study provided feedback for the common problems they had encountered in answering the questionnaire. In terms of the problems identified in the pilot test, the final questionnaire was edited and modified based on the feedback received to ensure that it was credible for the main study. The logistics of the main study followed a similar format as the pilot study while incorporating the updated questionnaire. It was e-mailed to all members within the DAC over a three month period. The analysis of the data will be based on the qualitative and quantitative methods that have been described in this chapter. The next chapter will present the results obtained from the questionnaires and discuss the key findings related to this study.

CHAPTER 4

STATEMENT OF FINDINGS AND DISCUSSION OF RESULTS

4.1 INTRODUCTION

This chapter will present a statement of the results and discuss the findings obtained from the questionnaires in the main study. As highlighted in the previous chapter, the questionnaire was one of the tools used to collect primary data from organisations in the KZN automotive sector. The data collected from the respondents will be analysed using the SPSS version 20.0. The results will be presented in the form of descriptive and inferential statistics. The descriptive statistics will include graphs, cross tabulations and figures while the inferential statistics makes use of correlations and chi-square values, which will be interpreted using the p-values. The layout of the chapter will consist of five sections as follows: section A (4.2) discusses the profile of the sample (pie and bar graphs), section B (4.3) reviews organisations that operate with the Lean technique (bar graphs), section C (4.4) analyses organisations that operate with Six Sigma (bar graphs), section D (4.5) investigates the requirements for Lean Six Sigma (mean scores, gaps, communality values, p-values and reliability) and section E (4.6) presents the existing quality improvement tools used in the sample organisations (bar graph). Due to the enrichment of discussions, there will be instances were one statistical technique will be favoured over the others.

The mean scores in section four are independent of Lean and Six Sigma organisations. In an attempt to understand the variation in responses for section four, there will be three categories of results presented as percentages. These are as follows: organisations that practice neither technique, organisations that practice Lean only and organisations that practice Lean and Six Sigma together. The levels of disagreement (negative statements) will be collapsed to show a single category of disagreement. A similar procedure will be followed for the levels of agreement (positive statements) to show a single category of agreement. In this manner, only three categories of results in percentage form will be presented as “disagree”, “neutral” and “agree”. This is allowed due to the acceptable levels of reliability and consistency in the factor analysis. The responses are more encouraging when they are combined and make the analysis easy to understand when interpreting the findings. A detailed summary of this chapter will be presented at the end.

4.2 PROFILE OF THE SAMPLE

This part of the analysis provides the demographical information of the respondents obtained from section A of the questionnaire. It includes information about their industry type, nature of their position, time spent in their current position and number of employees in the participating organisations. The last section categorises the participating organisations according to the type of technique they practice.

4.2.1 TYPE OF INDUSTRY

Figure 9 depicts the composition of the different types of industries in the automotive sector that participated in this study.

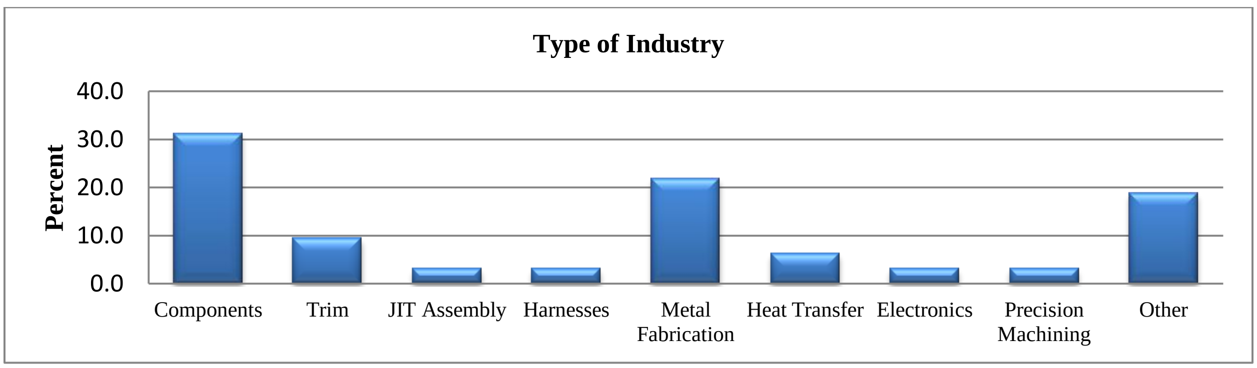


Figure 9 – Type of Industry

It can be gauged from Figure 9 that approximately one third (31.3%) of the sample are components manufacturers. A fairly high sample (21.9%) is represented by the metal processing industry. These two industries make up more than 50% of the sample and therefore can imply that they are common in the KZN automotive sector.

4.2.2 NUMBER OF YEARS EXPERIENCE OF THE RESPONDENTS

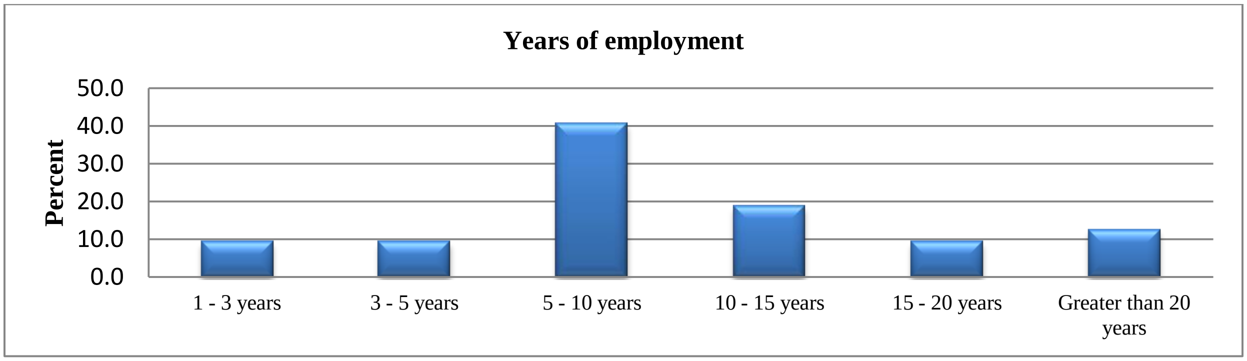


Figure 10 – Years of employment

The analysis from the years of employment in Figure 10 shows that the majority of the respondents (40.6%) have been in employment in the sample organisations for between 5 to 10 years, 18.8% between 10 to 15 years, 9.4% between 15 to 20 years and 12.5% greater than 20 years. It can, therefore, be inferred that the respondents have sufficient practical knowledge and experience of their organisations. One can also make an argument that the data collected could thus be used to draw significant conclusions.

4.2.3 NATURE OF THE RESPONDENTS POSITIONS

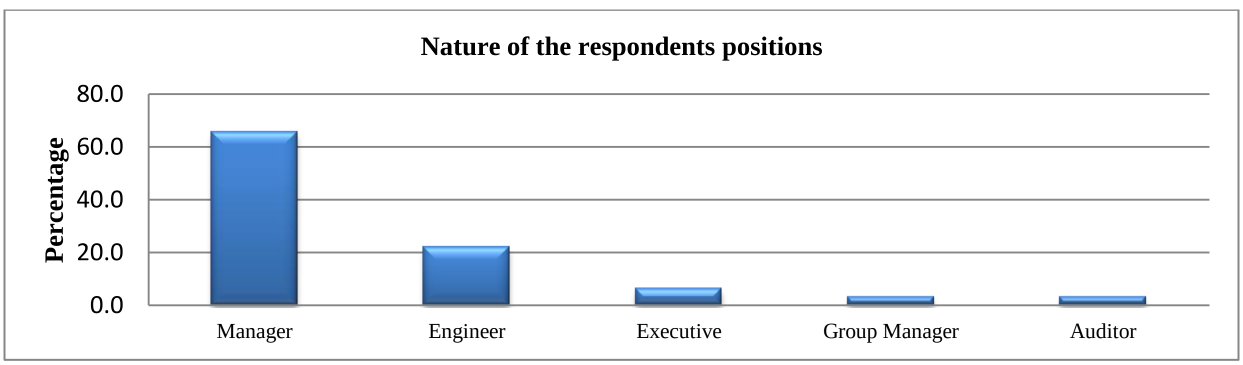


Figure 11 – Nature of the respondents positions

It is anticipated that the organisational level of the respondents would provide conclusive perceptions and experiences of the existing practices within their respective organisations. For example, a manager may not be biased and influenced by personal feelings of resentment towards the organisation when answering the questionnaire. The nature of positions of the realised sample is presented in Figure 11. From the results in Figure 11, it is evident that the questionnaires were completed mainly by managers (68.1%). The remainder of the questionnaires was completed by engineers (21.9%), executives (6.3%) and auditors (3.1%). Since the majority of respondents were managers (68.7%), it can be gauged that the sample represents the target population group of this research.

4.2.4 NUMBER OF EMPLOYEES

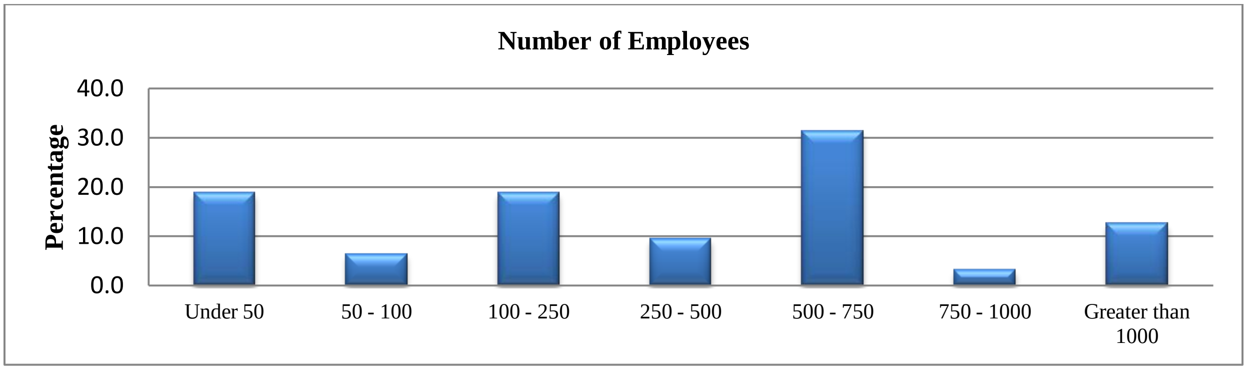


Figure 12 – Number of employees

It can be suggested that the number of employees dictates the size of an organisation. For example, an organisation with less than 50 employees would be categorised as a small organisation in comparison to an organisation with more than 1000 employees being categorized as a large organisation. Figure 12 reveals that 31.3% of the organisations have between 500 and 750 employees, 18.8% between 100 to 250 employees and 9.4% between 250 to 500 employees. This indicates that the majority of the organisations represented in this study (approximately 60%) can be classified as medium sized organisations.

4.2.5 TYPE OF TECHNIQUE PRACTICED

When a cross reference is made between Lean and Six Sigma, Figure 13 indicates that 28% of the organisations are using the Lean technique as a standalone system, 34% are using both Lean and Six Sigma techniques as standalone systems and 38% are using none of these techniques.

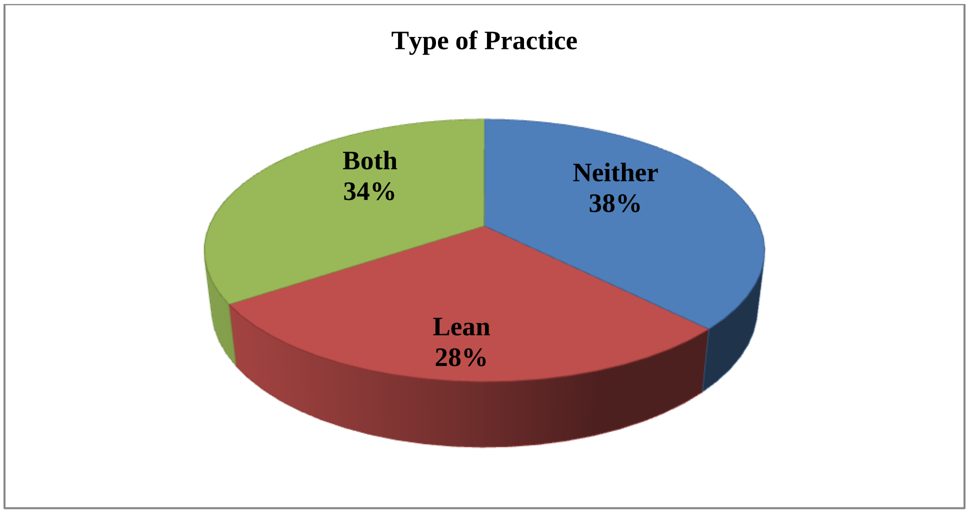


Figure 13 – Type of practice

In relation to Figure 13, it can be seen that there are no organisations that practice Six Sigma "only" as a standalone system. It appears that organisations practice some form of Lean initially and then include selected Six Sigma techniques into their operations later for additional improvement. For organisations which practice neither technique (38%), it can be surmised that the focus in these organisations may be more inclined towards productivity and meeting customers' deadline.

4.3 LEAN ORGANISATIONS

This section of the questionnaire was designed to establish the level of performance improvement experienced by organisations that practice the Lean technique. It includes qualitative and quantitative questions which allowed the respondents to clarify issues more intuitively. The information obtained in this section will identify the strengths and weaknesses of the Lean technique and clarify if Lean can achieve maximum performance improvement as a standalone technique.

Question 1.1 For how long is your organisation practicing Lean?

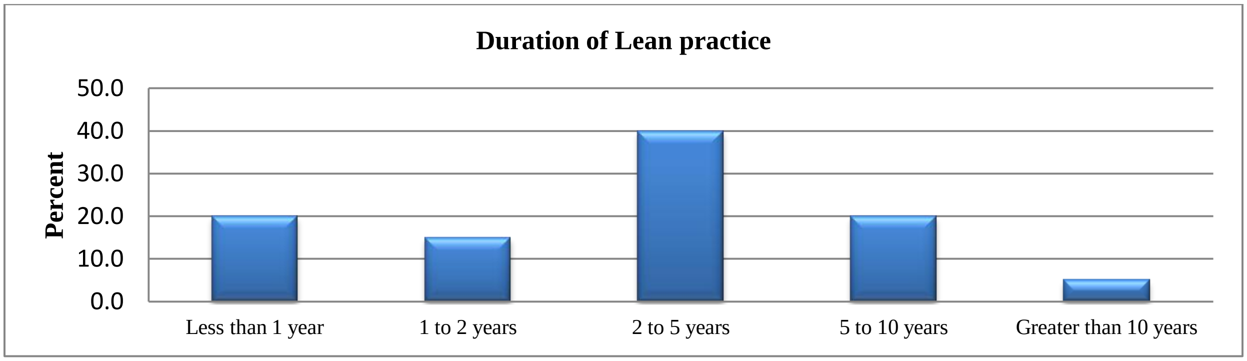


Figure 14 – Duration of Lean practice

Figure 14 show that the majority of organisations (40%) have been practicing the Lean technique between 2 to 5 years, 15% between 1 to 2 years and another 20% for less than 1 year. The remainder of the organisations have been practicing the Lean technique between 5 to 10 years (20%) and greater than 10 years (5%). This suggests that they have substantial knowledge and experience with the Lean technique. The result ties in with the theory of Shah and Ward (2007:785) who posit that Lean has emerged into a successful business improvement technique that has attracted organisations and become an integral part of the manufacturing landscape throughout the world over the last four decades.

Question 1.2 What was the reason for Lean deployment in your organisation?

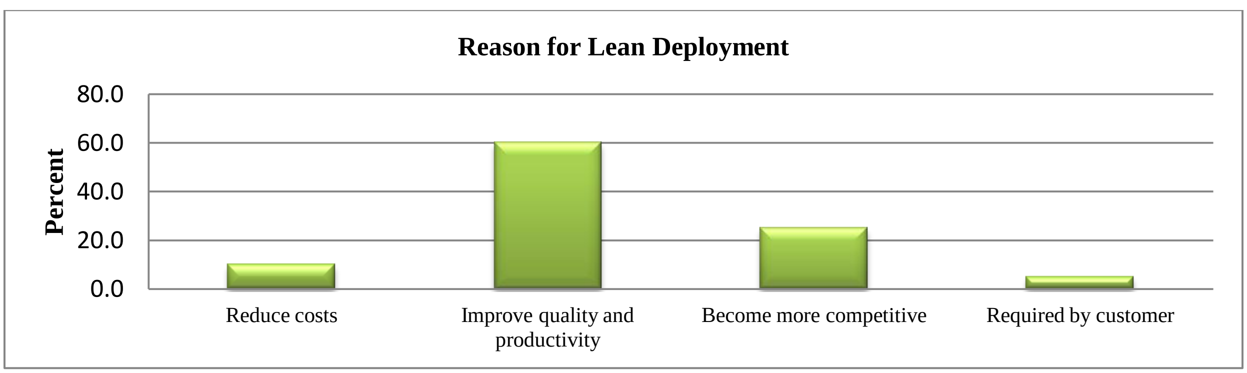


Figure 15 – Reason for Lean deployment

From the results presented in Figure 15, it can be seen that the majority of organisations (60%) deployed the Lean technique to improve quality and productivity, 25% wanted to enhance their competitiveness and another 10% intended to reduce costs. The remainder of the organisations (5%) implemented the Lean technique as a result of to their customers' request. This could perhaps be referring to the practice of JIT production where a customer may request their supplier to deliver the required parts, in the correct quantity and at the exact point in time. The result unites with Naslund (2008:275) who contends that JIT production assists an organisation to control the delivery rate of components from their suppliers.

Question 1.3 Did the management/leadership style change to accommodate Lean?

Seventy five percent of the respondents claimed that the management/leadership style changed to accommodate Lean. The common themes which arose between the respondents who agreed with this statement were predominantly changes in the organisations' corporate culture, management's extended support towards the employees and management's increased involvement with the daily operations. This result aligns with literature that an organisation requires significant cultural changes and a high degree of training and education of employees from upper management to the shop floor to operate Lean (Sim and Rogers, 2009:39; Bhasin and Burcher, 2006:58; Comm, 2005:71; Emiliani and Stec, 2005:384; Emiliani and Stec, 2004:630). The remainder of the organisations (25%) indicated that the management/leadership style did not change. The implication here is that if management did not embrace the expected change that was required to operate Lean, the employees would have likely followed a similar path. The findings reveal that a supportive organisational culture is an essential platform for the implementation of the Lean technique.

Question 1.4 Was Lean accepted by the diversity of employees in the organisation?

Eighty five percent of the organisations indicated that Lean was accepted by the diversity of employees. The common reason that sparked between the respondents was that the Lean technique was filtered into the organisations' processes and, therefore, the employees had to embrace the changes that were incorporated into their daily operations. The remaining 15% did not believe that this transformation had occurred. The negative responses could possibly be reflecting the employees' fear of retrenchment; this connects with Pepper and Spedding (2010:141) who claim that employees in Lean organisations feel a sense of insecurity and perceive Lean as a redundancy threat. The result suggests that organisations which implement improvement techniques such as Lean induces fear in employees; therefore, management support and assurance is necessary to remove these fears so that employees can embrace changes successfully.

Questions 1.5, 1.6, 1.7 and 1.8 are presented in Table 8.

Section B - Lean Organisations	Mean	Gap	Communality	p-value for question	Cronbach's Alpha
1.5) On a scale of 1 – 5 how would you rate the level of management/leadership commitment within the organisation to drive, live and demonstrate Lean behaviour	3.5	-1.5	0.844	0.017	
1.6) On a scale of 1 – 5 how would you rate the level of employee involvement to achieve the Lean goals.	2.7	-2.3	0.759	0.000	
1.7) On a scale of 1 – 5 how would you rate the level of the employees understanding towards Lean and where the business is heading	2.6	-2.4	0.806	0.000	
1.8) On a scale of 1 – 5 how would you rate the methods that the organisation has in place to continuously develop and sustain the Lean culture	3.3	-1.7	0.784	0.027	
Overall	3.0	-2.0	0.798		0.909

Table 8 – Results pertaining to questions 1.5, 1.6, 1.7 and 1.8 for Lean organisations

As depicted in Table 8, questions 1.5 and 1.8 have been positively answered (smaller gap values less than 2) while questions 1.6 and 1.7 have been negatively answered (larger gap values greater than 2). For question 1.5, the high level of "agreement" implies that the management/leadership within the organisations is enthusiastic and passionate about the transformation towards the Lean technique. This result complements the positive responses for question 1.8 regarding the development and sustainment of a Lean culture within the organisations.

Since questions 1.6 and 1.7 revolve around employee involvement and their understanding towards the Lean technique, they complement the scoring pattern of "disagreement". The negative responses suggest that some employees were not involved with the deployment process and thus have limited knowledge of the Lean technique. The Chi square values confirm this result as the gap scores are systematic of the response type. In this regard, the results show a weak relation that inhibits Lean implementation; this deviates from Fullerton and Wempe (2009:231) and Santos et al. (2006:4) that employee involvement at all levels in an organisation are the main components to ensure the successful adoption of the Lean technique. The discrepancy between the responses and the existing literature shows that there is a need for organisations to understand that employees are the key success factor to Lean implementation or any other business process change.

Question 1.9 How would you rate the success level of Lean adoption within the organisation?

60% of the organisations indicated that they had "some" success of Lean adoption and 40% revealed that many areas were successful. When the responses are combined, it echoes a similar sentiment as Andersson et al. (2006:288) that Lean is a continuous improvement technique which organisations have adopted with success. This success is achieved through the disciplined structure of the Lean technique which focuses on controlling resources in accordance with customers' needs while reducing unnecessary waste throughout the organisation.

Question 1.10 What activities are planned to improve Lean knowledge and practice in the organisation?

The similarities extracted from the responses indicate that training and awareness surface as the main focus areas to improve Lean knowledge and practice in the organisations. In terms of awareness, Comm and Mathaisel (2005:136) advise that it is the responsibility of the organisation's leadership to develop an environment in which it constantly provides information to the employees and encourages the same from them. The aspect on training clashes with Dahlgaard and Dahlgaard-Park (2006:279) that many Lean implementations focus primarily on training employees in tools and techniques rather than understanding the human factor and building the correct culture. Perhaps this is the underlying reason organisations sometimes find it difficult to successfully adopt the Lean technique.

Question 1.11 Please select from the list of improvements presented all those that occurred within the organisation since the adoption of the Lean technique.

The elimination of waste (100%), the reduction in cycle times (80%) and the establishment of visual management techniques (80%) emerged as the top three improvements which had occurred in the organisations since the adoption of the Lean technique. These were closely followed by improvement in space utilization (65%), reduction in WIP and finished goods inventory (65%), improvement in quality (65%) and improved speed and responsiveness to customer needs (60%). This finding blends in with the literature that Lean has attracted many organisations because it results in various types of improvements that are related to quality, productivity and customer satisfaction (Nauhria et al., 2009:37; Evans, 2008:268; Andersson et al., 2006:289; Mathaisel, 2005:624; Evans and Lindsay, 2005:176; Gupta, 2005:425-426).

Question 1.12 What deficiencies have been identified with the Lean technique since its inception?

The following similarities were extracted from the total responses to this question. They are categorised as: difficult to maintain JIT production, operators are not included in all problem solving investigations, unable to keep inventory to a minimum and difficult to achieve one piece flow. The difficulty of maintaining JIT production and one piece flow relates mutually with Arnheiter and Maleyeff (2005:10) that very few Lean organisations have pure single piece flow systems throughout their entire operation. The findings also support the work of Andersson et al. (2006:289) who maintain that Lean cannot be applied in organisations where customer demand is unstable and unpredictable. It appears that Lean reduces flexibility, causes congestion in the supply chain and is not applicable in all industries.

Question 1.13 Aside from the improvements that Lean brings to the workplace, does the organisation focus on the following improvement areas?

The aim of this question was to investigate whether organisations focus on other improvement areas aside from Lean. The commonalities extracted from the respondents revealed that more focus is required in reducing defects and customer complaints, creating a structured problem solving approach and maintaining stable processes. This gives an indication that Lean as a standalone technique has limitations in improving an organisation's overall performance. These limitations are the key focus areas of the Six Sigma technique, as highlighted in the literature (Thomas et al. 2009:114; Arnheiter and Maleyeff, 2005:17). This suggests that an organisation which operates with the Lean technique as a standalone system does not consider the importance of reducing process variation, which Six Sigma aims to eliminate. Therefore, it can be regarded as the foundation or building block for embracing the intergrated Lean Six Sigma technique.

Question 1.14 In relation to the previous question, do you think the Lean technique is achieving perceived business performance in the organisation?

The majority of the respondents claim that Lean is not achieving perceived business performance. Some of the common reasons that surfaced between the respondents are that the organisations are still experiencing high customer complaints and excessive defect levels although the Lean technique was successfully deployed in their organisations. A possible interpretation could be related to the results from question 1.13 where Lean does not focus on reducing process variation. The literature indicates that reducing process variation would produce robust manufacturing processes that are able to minimise defects and generate lower costs of poor quality (Mehrjerdi, 2011:79; Barnes and Walker, 2010:25; Foster, 2010:424; Savolainen and Haikonen, 2007:8; Kumar, Saranga, Ramirez-Marquez and Nowicki, 2007:426; Goh and Xie, 2004:235). Perhaps it can be suggested that management also use structured performance evaluators and follow up procedures to monitor the Lean processes to ensure sustainability of the system.

Question 1.15 What is your overall perception of Lean?

The consistency in positive responses indicates that the Lean technique has effective measures to improve an organisations performance. Some of these effective measures include simple tools such as 5S and Standardisation which is easy to understand and apply by the operators. The results engage with Gupta (2005:426) that Lean promotes better housekeeping, more organised workspace, higher inventory turns, and motivated employees.

4.4 SIX SIGMA ORGANISATIONS

This section of the questionnaire was designed to establish the level of performance improvement experienced by organisations that practice the Six Sigma technique. At this stage it is deemed necessary to highlight the context in which the questionnaire regarding Six Sigma was approached. On completion of the main study it was found that the sample consisted of organisations practicing either Lean and Six Sigma as standalone techniques, while others practiced Lean “only” as a standalone technique, however none of the organisations practiced or could be regarded as a Six Sigma “only” organisation. Therefore, the feedback received from the respondents for the section of Lean and Six Sigma as standalone techniques was interpreted in the context of the organisation being a Lean "only" and a Six Sigma "only" organisation. For example, if the organisation is practicing both Lean and Six Sigma techniques, they should answer Lean and Six Sigma as separate entities. This section includes qualitative and quantitative questions which allowed the respondents to clarify issues more intuitively. The information obtained in this section will identify the strengths and weaknesses of the Six Sigma technique and clarify whether Six Sigma can achieve maximum performance improvement as a standalone technique.

Question 1.1 For how long is your organisation practicing Six Sigma?

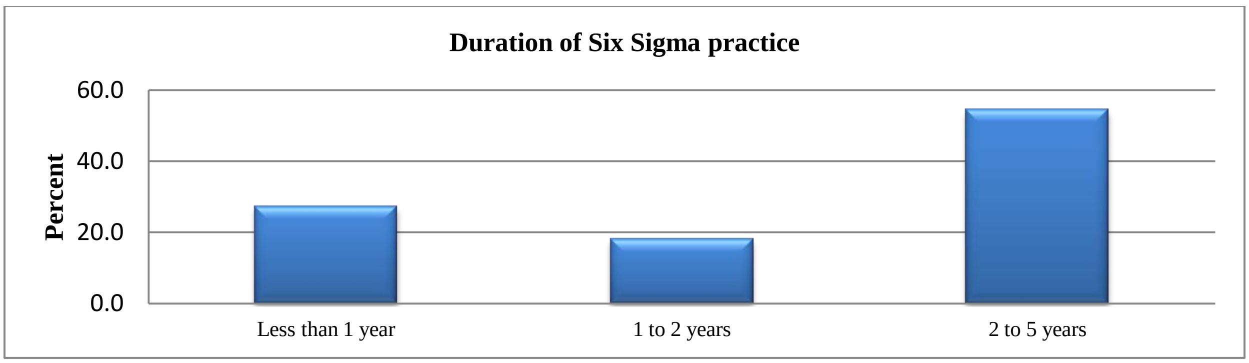


Figure 16 – Duration of Six Sigma practice

From Figure 16, it is evident that the majority of organisations are practicing the Six Sigma technique between 2 to 5 years (55%), 27% less that 1 year and another 18% between 1 to 2 years. One can thus infer that the results links with the theory that Six Sigma is not popular as compared to the Lean technique. This finding unites with Pulakanam and Voges (2010:155) and Shah et al. (2008:6680) that Six Sigma is still an emerging concept when compared to Lean. This could be due to insufficient knowledge of the Six Sigma technique or lack of resources and implementation costs.

Question 1.2 What was the reason for Six Sigma deployment in your organisation?

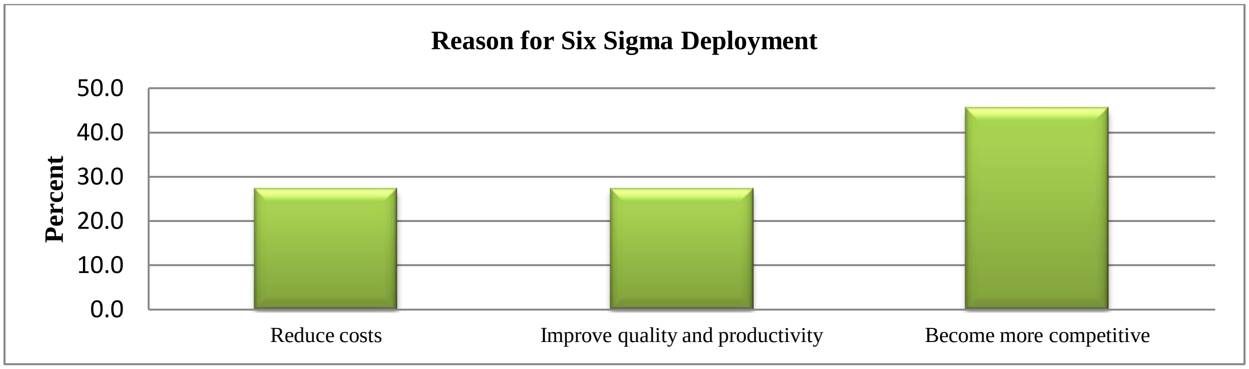


Figure 17 – Reason for Six Sigma deployment

Figure 17 illustrates that the majority of organisations (46%) deployed the Six Sigma technique to become more competitive, 27% wanted to reduce costs and the remaining 27% indicated an intent to improve quality and productivity. It can be interpreted that the different reasons for implementing Six Sigma have a common goal which is to improve the profitability of an organisation. This corresponds with literature that Six Sigma appeals to top executives because it focuses on measurable profit margins that are achieved through the reduction in process variation while creating a state of process excellence (Snee, 2010:10-11; Montgomery, 2010:61; Chakrabarty and Chuan, 2009:615; Morgan and Brenig-Jones, 2009:15; Shah et al., 2008:6681; Schroeder et al., 2008:540; Naslund, 2008:271; Andersson et al., 2006:286; Bendell, 2006:256; Black and Revere, 2006:259-260; Antony et al., 2005:860; Raisinghani et al., 2005:499; Evans and Lindsay, 2005:3; Liker, 2004:296).

Question 1.3 Did the management/leadership style change to accommodate Six Sigma?

78% of the respondents claimed that the management/leadership style did not change to accommodate the Six Sigma technique. The main reason that arose between the respondents centered on the point that Six Sigma was implemented as a continuous improvement tool rather than a management philosophy. The remaining 22% of the organisations indicated that there were noticeable changes in management's leadership style and their commitment to the Six Sigma technique. An expectancy explanation of this result comes from McCarty and Fisher (2007:190) who identified that invigorating leadership is needed to support the organisation and employees to sustain the Six Sigma technique. This implies that good leadership would foster effective skills and knowledge advancement amongst the employees towards the sustainment of the Six Sigma goals.

Question 1.4 Was Six Sigma accepted by the diversity of employees in the organisation?

Approximately 90% of the respondents claimed that the Six Sigma technique was not accepted by the diversity of employees in the organisations. The common reasons that surfaced from the negative responses were mainly attributed to the organisation not communicating and informing the employees about the Six Sigma technique. In addition, only selected employees were exposed to the Six Sigma technique. These results differ from Starbird and Cavanagh (2011:78-79) who claim that all employees should be included during the implementation of new technologies as a means of gaining their acceptance for changes that may occur in their existing processes. It can be interpreted that involving all employees in organisational changes would eliminate resistance to change among employees and will also capture the creativity, energy and ideas from everyone in the organisation.

Questions 1.5, 1.6, 1.7 and 1.8 are presented in Table 9.

Section C - Six Sigma Organisations	**Mean**	**Gap**	**Communality**	**p-value for question**	**Cronbach's Alpha**
1.5) On a scale of 1 – 5 how would you rate the level of management/leadership commitment within the organisation to drive, live and demonstrate Six Sigma behaviour	2.7	-2.3	0.883	0.079	
1.6) On a scale of 1 – 5 how would you rate the level of employee involvement to achieve the Six Sigma goals	2.9	-2.1	0.891	0.045	
1.7) On a scale of 1 – 5 how would you rate the level of the employees understanding towards Six Sigma and where the business is heading	2.3	-2.7	0.883	0.497	
1.8) On a scale of 1 – 5 how would you rate the methods that the organisation has in place to continuously develop and sustain the Six Sigma culture	2.4	-2.6	0.891	0.273	
Overall	2.6	-2.4	0.887		0.955

Table 9 – Results pertaining to questions 1.5, 1.6, 1.7 and 1.8 for Six Sigma organisations

The results for questions 1.5, 1.6, 1.7 and 1.8 are summarised in Table 9 and show that there is general consensus of “disagreement” for these questions (mean values less than 3). The negative responses for question 1.5 could possibly mean that the organisations have not committed to aligning the Six Sigma technique with their business strategy. This contradicts the work of

Pepper and Spedding (2010:144) that management commitment and open communication are essential for the success of the Six Sigma technique.

In relation to question 1.6, the negative scoring pattern and significant Chi square value could perhaps be reflecting the level of involvement the employees share in Six Sigma projects. Since literature indicates that only selected employees are required to participate in Six Sigma projects, it could result in the remainder of the employees feeling discouraged if they are not included in improvement projects that relate to their processes. This finding deviates from Przekop (2006:36) who claims that although Six Sigma requires selected improvement specialists to work on improvement projects, all employees should participate in improvement discussions regarding processes for which they are responsible. The responses for question 1.7 and 1.8 signal the need for organisations to establish training workshops to communicate the positive effects of the Six Sigma technique. Since question 1.8 relates to culture change, the results point in the direction that the organisations have not blended the Six Sigma technique into their operational culture as suggested by Thevnin (2004:199).

Question 1.9 How would you rate the success level of Six Sigma adoption within the organisation?

All organisations indicated that they had some "success" of Six Sigma adoption. The positive results could perhaps be referring to completed Six Sigma projects that produced significant improvements in the organisations. This seems to suggest that the success of Six Sigma depends on how it is implemented and sustained within the organisations. The findings associate with Lee-Mortimer (2006:17) that Six Sigma requires comprehension of the implementation issues which need to be resolved along with commitment and effort to pursue successful improvement projects.

Question 1.10 What activities are planned to improve Six Sigma knowledge and practice in the organisation?

The responses to this question show a similar pattern where training and awareness emerges as the main issue that needs to be improved. Although literature highlights that selected employees participate in Six Sigma projects, the results are compatible with Evans and Lindsay (2005:65) who advise that managers must show commitment and support to the Six Sigma technique by providing the correct training and awareness to all employees on a continual basis.

Question 1.11 Please select from the list of improvements presented all those that occurred within the organisation since the adoption of the Six Sigma technique.

This question was designed to gauge the list of improvements that occurred within the organisations through the Six Sigma technique. The common improvements that occurred within the organisations were the implementation of Statistical Process Control (82%), reduction in process variability (82%), uniform process output (72%), process capability and stability (72%), and systematic problem solving approach (72%). All of these improvements relate mutually to the aim of Six Sigma which is to remove variation from processes and to manufacture defect free products. The results supplement the literature that Six Sigma is considered a business strategy and a science that combines statistical and business methodologies which focus on continuous and breakthrough improvements to reduce manufacturing costs, improve customer satisfaction and to predictably produce world class products and services (Noone et al., 2010:275; Thomas et al., 2009:113-114; Antony and Desai, 2009:413; Banuelas et al., 2006:514).

Question 1.12 What deficiencies have been identified with the Six Sigma technique since its inception?

The common theme that arose from the respondents to this question is the long duration of improvement projects and the difficulty in understanding the statistical tools. The most indicative statements supporting the deficiencies of the long project duration links to the complexity of the DMAIC cycle, as highlighted by Morgan and Brenig-Jones (2009:36) and Bendell (2006:259). Central to this issue is the concern that additional defects may be produced if the identified problem is not resolved immediately which could result in excessive cost of poor quality. The difficulty of understanding the statistical tools in Six Sigma collaborates the findings of Pepper and Spedding (2010:145) that Six Sigma has long been seen as a statistics-heavy, technical approach to process control.

Question 1.13 Aside from the improvements that Six Sigma brings to the workplace, does the organisation focus on the following improvement areas?

The intent of this question was to supplement question 1.12 by identifying whether organisations focus on other improvements areas aside from Six Sigma. The responses to this question, along similar themes, were: Six Sigma does not focus on reduction in inventory, on time delivery performance, identification of non-value added activities and reduction in cycle times. It can be inferred from the data that even though organisations have Six Sigma practices in place, there is still an existing gap of meeting other organisational performance measures which Lean seeks to eliminate. This finding challenges the assumption that Six Sigma can lead to superior performance improvement. The results of the analysis mean that Six Sigma has limitations which are favourable to the Lean technique and therefore corresponds with Thomas et al. (2009:114) and Arnheiter and Maleyeff (2005:17-18) that in order to achieve overall performance improvement, Lean may be needed to work in conjunction with Six Sigma.

Question 1.14 In relation to the previous question, do you think the Six Sigma technique is achieving perceived business performance in the organisation?

Most of the respondents do not believe that the Six Sigma technique is achieving perceived business performance. The common reasons that arose among the respondents are that Six Sigma is only restricted to selected improvement specialists and there is no focus on quick solutions to simple problems. These findings strengthen the literature that Six Sigma does not consider solutions for quick financial gains but instead it focuses on a systematic approach to problem solving that is largely dependent on the quality of data required for conducting statistical analysis (Nauhria et al., 2009:38; Su et al., 2006:6).

Question 1.15 What is your overall perception of Six Sigma?

Several of the respondents indicated that the Six Sigma technique is a high level process for advanced problem solving. They claim that the statistical and mathematical tools make it difficult for the average employee on the shop floor to utilise. Another common theme that arose among the respondents is that Six Sigma is a good systematic problem solving tool that is similar to the PDCA cycle.

4.5 LEAN SIX SIGMA SUCCESS FACTORS

The focus of this part of the questionnaire was to determine the existing manufacturing practices of the organisations in this study. It comprises of seven investigation areas that links questions related to the principles recommended for the Lean Six Sigma technique. These investigation areas include: organisational infrastructure, management commitment and leadership, commitment to quality, production control, process improvement, employee involvement and customer focus.

4.5.1 ORGANISATIONAL INFRASTRUCTURE

The purpose of this section is to establish how the respondents rate their existing organisational infrastructure in terms of their goals, employees, processes and management systems. The responses provided by the respondents could provide opportunities for organisations to improve their existing infrastructures. The overall results from the survey data pertaining to this section is demonstrated in Table 10. These include mean scores, gaps, communalities, p-values and reliability. The reasons for selecting the aforementioned statistical data to evaluate the results were explained in chapter 3.

Question 1 - Organisational Infrastructure	Mean	Gap	Communality	p-value for type of practice	Cronbach's Alpha
1.1) All processes and policies within the organisation are well defined and maintained	2.8	-2.2	0.748	0.049	
1.2) The organisation's strategies are focused on goals and results to achieve competitive advantage	2.7	-2.3	0.730	0.026	
1.3) The organisation commits to modifying systems and structures to support business assurance	3.4	-1.6	0.527	0.267	
1.4) The organisation respects and supports the diversity of different cultures	3.3	-1.7	0.751	0.421	
1.5) A culture of continuous improvement is visible on the shop floor and throughout the organisation	2.8	-2.2	0.713	0.194	
Overall	3.0	-2.0	0.694		0.886

Table 10 – Results pertaining to organisational infrastructure

It can be noted from Table 10 that the average score for this section is 3. Since the responses for questions 1.3 and 1.4 have higher mean values (greater than 3) it can be interpreted that these questions are positively inclined towards “agreement”. The result for question 1.3 suggests that organisations are keen to keep up with updated technology. This aligns with Mehrjerdi (2011:81) who suggests that the implementation of new technologies is one way of modifying systems and structures to support business assurance. In response to question 1.4, the results show that the ethnic and racial divisions in the KZN business climate make it imperative for the organisations to manage the cultural diversity among employees. This result associates with the literature of the cultural changes that are required in organisations when implementing Lean or Six Sigma techniques (Sim and Rogers, 2009:39; Zu et al., 2008:644; Bhasin and Burcher, 2006:58; Comm, 2005:71; Emiliani and Stec, 2005:384; Emiliani and Stec, 2004:630; Haikonen et al., 2004:377).

Questions 1.1, 1.2, and 1.5 showed smaller mean values (less that 3). This indicates a degree of “negativity” since the 5-point Likert scale represents 3 as “neutral”. These questions have larger gaps and will therefore require closer inspection of the scoring patterns. The scoring patterns will be evaluated between the different practices grouped as percentages. To this end, the data will be grouped into organisations as follows: those that practice the Lean technique only, organisations that incorporate Lean and Six Sigma together and organisations that incorporate neither technique. The overall community value of 0.694 in Table 10 indicates that the questionnaire model is explaining variations 69% of the time. The Cronbach’s Coefficient Alpha of 0.886 maintains the high reliability for the established scales. The Chi square test per question confirms the mean scores were not random, but are indicative of the response type. There are different levels of agreement from respondents for the first 2 statements ($p<0.05$). This indicates that the first 2 statements are significantly related to the type of technique practiced. Hence, the respondents’ type of technique adopted did play a role in terms of how the statements were scored. Further analysis of the focal points (question 1.1, 1.2 and 1.5) are presented next to establish why the above results differ in relation to the type of technique practiced.

The results in percentages for question 1.1 by the type of technique practiced, is represented by Figure 18.

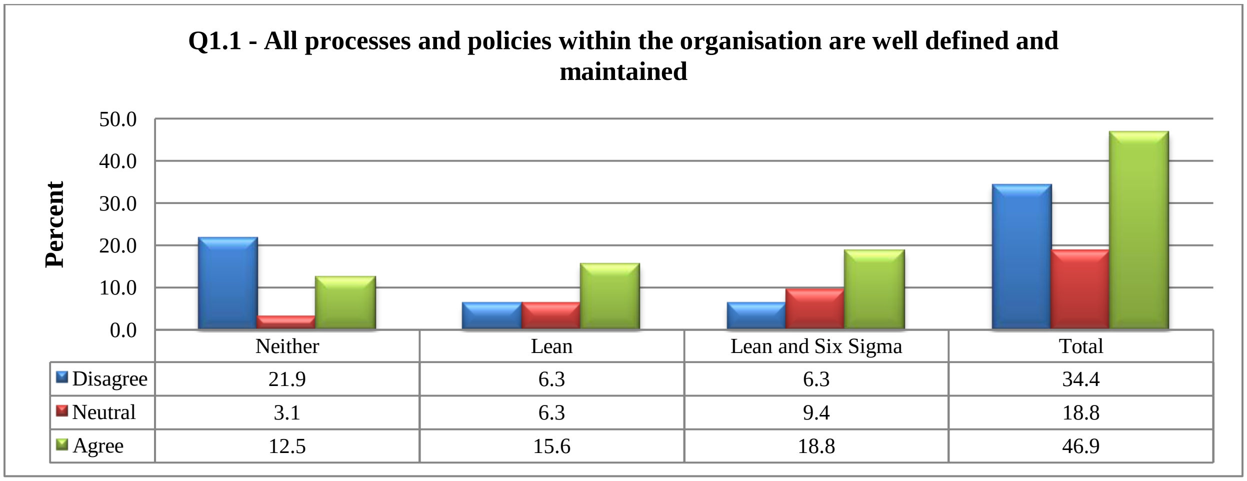


Figure 18 – Type of technique practiced response for question 1.1

As presented in Figure 18, more that 40% of the total respondents “agreed” with question 1.1 while approximately 35% “disagreed”. When the data is split between the types of practice, it is noted that 15.6% of organisations that practiced Lean only and 18.8% of organisations that practice both techniques “agree” that they have well defined processes and procedures in their organisations. The striking observation is that 21.9% of the total 37.5% of organisations that practice neither technique “disagreed” with the statement. This finding seems to indicate that organisations which have improvement programs such as Lean and Six Sigma are likely to have clearly defined processes and procedures within their organisations.

The overall high level of “disagreement” obtained in Figure 18 contests what Emiliani and Stec (2005:373) and Liker (2004:152) argue: that clearly defined processes and procedures allows employees to understand their roles and responsibilities within predefined limits which is the strategic link between the organisation’s vision and day to day operations. This is also in contrast with Morgan and Brenig-Jones (2009:137) who claim that undefined processes and procedures can lead to waste by inappropriate processing, as discussed in section 2.6.4. The data supports the conclusion that organisations may not understand the details of their businesses’ processes until they are well defined and maintained. This means that organisations which have undefined processes and procedures will have insufficient control mechanisms in place to manage their daily operations. This could result in quality not improving and possibly impact on customer satisfaction.

The result in percentages for question 1.2 by the type of technique practiced is represented by Figure 19.

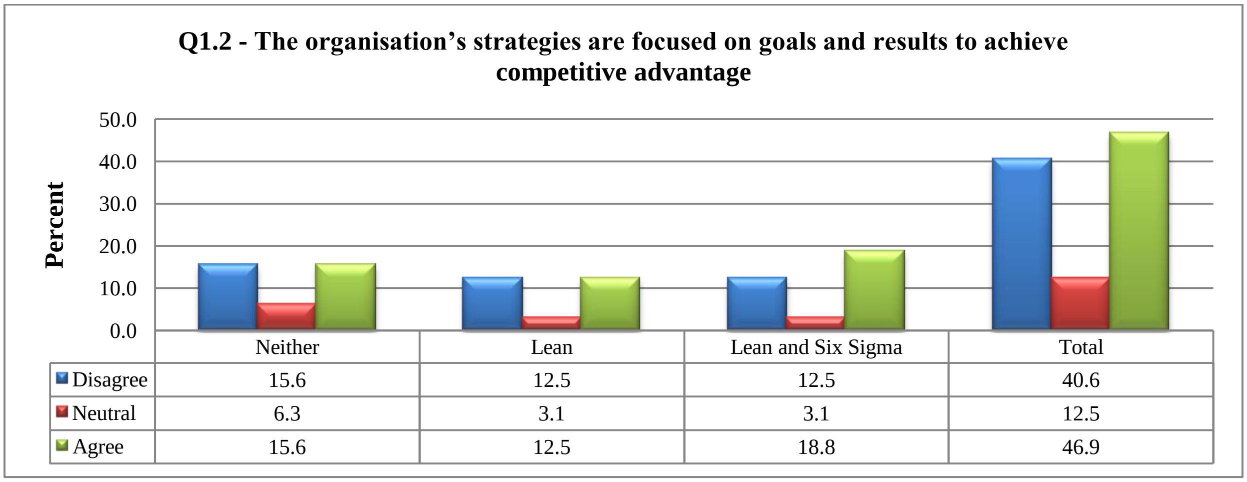
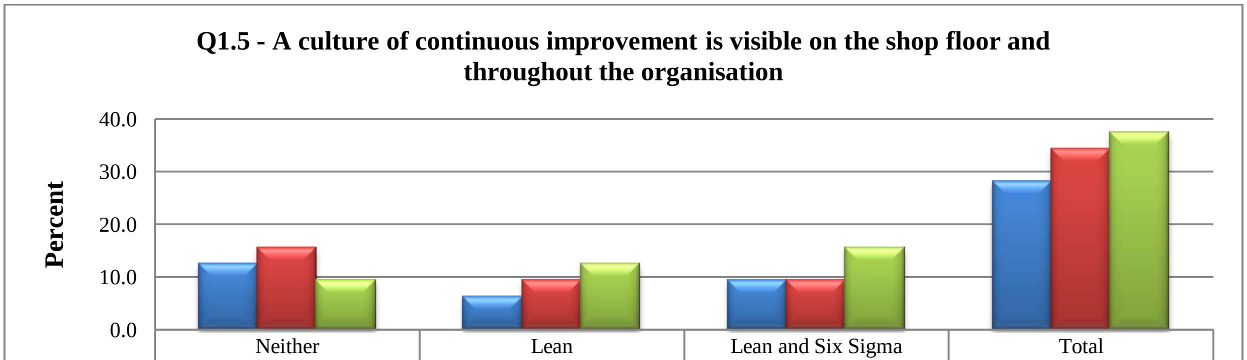


Figure 19 – Type of technique practiced response for question 1.2

From the total responses in Figure 19, it can be seen that organisations which practice both techniques have a majority of "agreement" (18.8%) in contrast to organisations which practice neither technique indicating the highest "disagreement" (15.6%) for this statement. The high level of "agreement" within organisations that practiced the Six Sigma technique is congruent with Noone et al. (2010:275), Thomas et al. (2009:113-114), Antony and Desai (2009:413) and Banuelas et al. (2006:514) that the Six Sigma technique increases an organisation's focus towards its strategic objectives to sustain a competitive advantage in the business world. This means that organisations which strategically manage the business are able to increase their operational effectiveness by increasing sales, profits and efficiency.

Taking note of the combined percentage of respondents who were "neutral" and "disagreed" with this statement (more than 50%), it could possibly mean that they are not familiar with their organisation's strategies or have no formal strategy formulation process in place. These results could imply that management does not filter the strategic objectives to employees which contradicts the views of Banuelas et al. (2006:516) and Thevnin (2004:198) who contend that top management commitment and leadership are responsible for cascading the organisation's strategy into specific improvement projects as a means of ensuring its success. Therefore, it can be inferred from these findings that management needs to convey the organisation's strategies to employees so that they have a clear understanding on the direction of the organisational goals and the means of attaining these goals.

The result in percentages for question 1.5 by the type of technique practiced is represented by Figure 20.



	Neither	Lean	Lean and Six Sigma	Total
Disagree	12.5	6.3	9.4	28.1
Neutral	15.6	9.4	9.4	34.4
Agree	9.4	12.5	15.6	37.5

Figure 20 – Type of technique practiced response for question 1.5

As can be seen in Figure 20, there is a consistent trend of "agreement" by organisations that have improvement systems in place, which comprise 28.1% of the total sample, for this question. This result corroborates with the findings of Shah et al. (2008:6683) who espouse that the Lean and Six Sigma techniques engage employees to continuously improve their processes on an ongoing basis. On the other hand, it is observed in Figure 20 that organisations which practiced neither technique showed a higher trend of "disagreement" (12.5% of the total 37.5%) compared to the other two categories. This may have been directly related to various functions having to perform different techniques with regard to continuous improvement. However, since the goal of continuous improvement is to investigate existing processes and discover more efficient and effective methods of manufacturing, the responses of "disagreement" (28.2%) contradicts the work of Bhuiyan and Baghel (2005:761) and Comm (2005:65) who indicate that continuous improvement should focus on employees working together to make ongoing improvements to their processes and it should have no restrictions or boundaries.

Essentially, this means that a team culture is needed so that employees can engage their collective expertise effectively and sustain a motivating work environment to implement improvements that involve small steps and gradual progress which are less likely to require major capital investment. It can therefore be argued that the high level of "disagreement" and "uncertainty" stems from the organisation's inability to make continuous improvement part of their culture. This observation was also highlighted by Sim and Rogers (2009:46) and correlates with Salah et al. (2010:249-250) who document that the success of continuous improvement requires a change in the employees mindset and depends on how continuous improvement is implemented and maintained within an organisation. Perhaps it can be suggested that since culture represents the personality of an organisation, a culture of continuous improvement would encourage employees to grow, learn and contribute to the pursuit of perfection in all products and processes owing to the intensifying dynamic market trends and the variety of demands that the customer places on products and services.

4.5.2 MANAGEMENT COMMITMENT AND LEADERSHIP

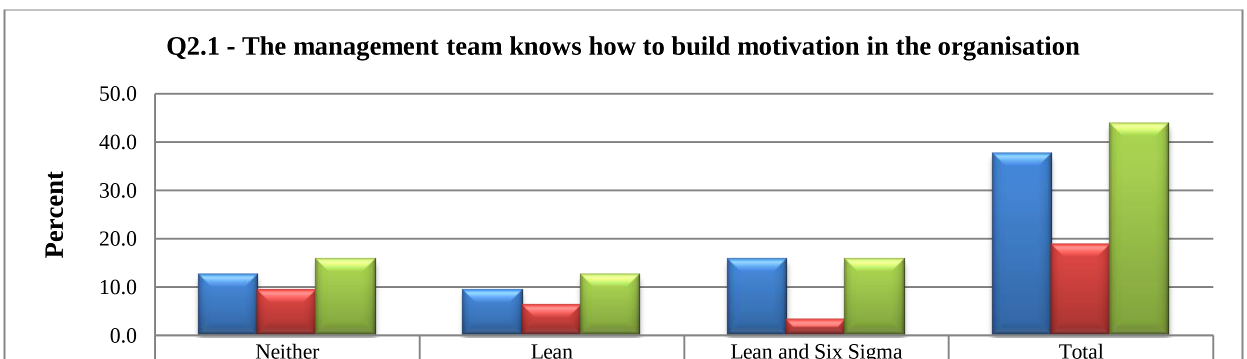
In terms of management commitment and leadership, this section evaluates how the management team embraces their objectives, both by challenging and motivating the employees. The questions structured around this section aim to evaluate the responses of managements' direct involvement with the employees and the processes. The individual scores for each question and overall ratings for this section are presented in Table 11.

Question 2 - Management Commitment / Leadership	Mean	Gap	Communality	p-value for type of practice	Cronbach's Alpha
2.1) The management team knows how to build motivation in the organisation	2.8	-2.2	0.550	0.036	
2.2) Management has arrangements to support skills, experience and competence retention	3.2	-1.8	0.725	0.004	
2.3) Managers go to where the action takes place (Gemba)	2.8	-2.3	0.760	0.001	
2.4) Management defines the appropriate roles and responsibilities within the organisation	2.9	-2.1	0.770	0.024	
2.5) Management provides continuous feedback to employees on their performance	2.8	-2.2	0.815	0.011	
Overall	2.9	-2.1	0.724		0.902

Table 11 – Results pertaining to management commitment and leadership

The average score for this section, as depicted in Table 11 is 2.9. Apart from question 2.2, the scoring pattern for the remainder of the questions has been answered negatively. The high level of agreement for question 2.2 means that organisations do indeed see the benefit of retaining competent employees. This could be in the form of providing training or multi-skilling which correlates with Olivella et al. (2008:804) who advocate that multi-skilling employees enables more flexibility between operations and facilitates learning and continuous improvement. The low Chi square values for each question in this section highlights that there are significant relationships as $p<0.05$. This suggests that the responses varies between organisations, however, the type of technique does impact management commitment and leadership. For example, Lean concentrates on management support and effective communication to work synergistically together while Six Sigma alternatively focuses on a strong leadership structure (McCarty and Fisher, 2007:190; Worley and Doolen, 2006:243; Gupta, 2005:22). As can be seen in Table 11, 72% of the variation is explained by the questionnaire model and the value 0.902 indicates a high level of reliability for this section. The concept of motivation seems to resonate with the respondents. An investigation of the variation in responses from the larger gap scores for questions 2.1, 2.3, 2.4 and 2.5 by the type of technique practiced, follow.

The result in percentages for question 2.1 by the type of technique practiced is represented by Figure 21.



	Neither	Lean	Lean and Six Sigma	Total
Disagree	12.5	9.4	15.6	37.5
Neutral	9.4	6.3	3.1	18.8
Agree	15.6	12.5	15.6	43.8

Figure 21 – Type of technique practiced response for question 2.1

From the analysis in Figure 21, it is evident that there is a general trend of “agreement” for this statement. There is also a substantial level of “disagreement” (37.5% in total) which could possibly be reflecting personal feelings of respondents who are not motivated by management or could have been shown disrespect by management at some point. On the other hand, this could be a true reflection of the results as it correlates with the findings of Sim and Rogers (2009:37-

46) who found in their study that shop floor employees (referred to as operators) do not believe that the organisation views them as the most important asset and require constant motivation. This finding suggests that employees would enjoy a work environment where they are respected and valued for their contributions.

From a theoretical perspective, the portion of agreement for organisations that practice the Six Sigma technique (15.6% of the total 34.4%) is consistent with the findings from literature which indicates that Six Sigma requires managers to motivate employees to innovate and improve their work environment and ultimately their satisfaction on the job and personal self-esteem (Gupta, 2005:455; Evans and Lindsay, 2005:68). It can therefore be assumed that motivated employees will perform their responsibilities more effectively as it would inspire and encourage them to participate and contribute their talents and experience. A motivating environment occurs when employees are pushing themselves harder.

The result in percentages for question 2.3 by the type of technique practiced is represented by Figure 22.

	Neither	Lean	Lean and Six Sigma	Total
Disagree	18.8	12.5	9.4	40.6
Neutral	6.3	3.1	3.1	12.5
Agree	12.5	12.5	21.9	46.9

Figure 22 – Type of technique practiced response for question 2.3

From the total responses represented in Figure 22, 40.6% “disagreed”, 46.9% “agreed” and 12.5% were “unsure” with the statement. It is interesting to note that the high level of disagreement for the two categories that practice Lean (21.9% of the total 40.6%) deviates from the findings of Morgan and Brenig-Jones (2009:67) who point out that this technique originated in Japan through the Lean technique. On the other hand, 34.4% of the total 40.6% that positively “agreed” with this statement was mainly attributed to organisations that have improvement systems. This finding indicates that management sees the benefit of frequently making their way to the production environment as a means of understanding what is really happening in each process. The data coincides with Salah et al. (2010:270) who suggest that continuously visiting the workplace allows the management team to identify opportunities for improvement on an ongoing basis.

It is probable that when the management team frequently visits the production environment, they would reinforce the standards of the organisation by ensuring each process is correctly aligned with the measures used to evaluate the entire operation. Additionally, it will also allow the management team to identify problems that could have possibly been overseen by the employees at the respective processes. It can therefore be concluded that "Gemba" would bring together managers, engineers and employees to perform quick investigation analysis for problems as they occur. This can also be viewed as a means of showing respect and motivation between the management team and the shop floor employees to foster an alignment of the organisational goals.

The result in percentages for question 2.4 by the type of technique practiced is represented by Figure 23.

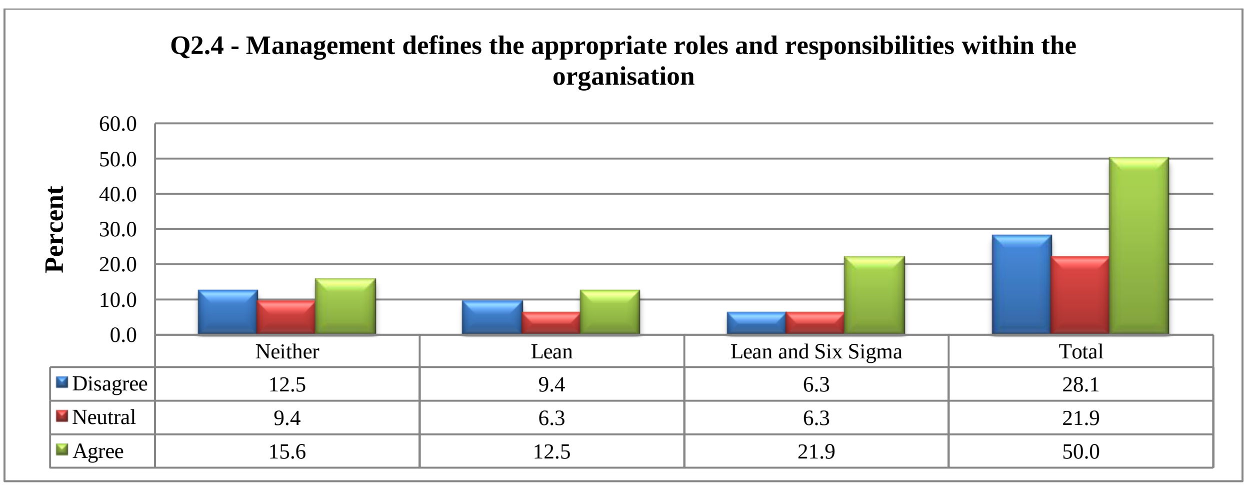
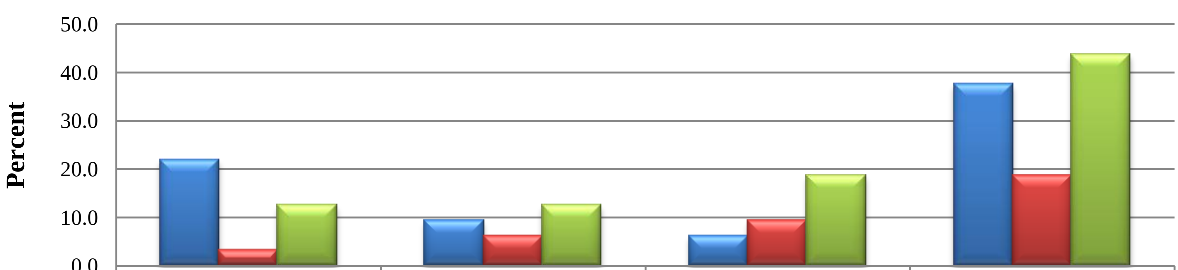


Figure 23 – Type of technique practiced response for question 2.4

Figure 23 shows a general trend of "agreement" for this statement. This implies that the majority of respondents have aligned organisational infrastructures with clearly defined roles and responsibilities for improvement projects. However, since the largest portion of "agreement" stems from organisations which practice the Six Sigma technique, the finding concurs with the views of the various authors that Six Sigma requires the development of a hierarchy of process improvement specialists who are equipped with the tools and knowledge to make significant improvements in the business (Montgomery, 2010:62; Kumar et al., 2009:682; Montgomery and Woodall, 2008:332; Savolainen and Haikonen, 2007:9; Su et al., 2006:3; Andersson et al., 2006:287; Haikonen et al., 2004:372; Goh and Xie, 2004:237). The result also aligns with Karthi et al. (2011:313) who demonstrate the different roles and responsibilities that are needed for working on improvement projects in a Lean Six Sigma environment. It can thus be suggested that when employees are given clearly defined roles and responsibilities, it provides them with a better understanding of the job and tasks they are to perform as an individual and within teams of which they are part. This will directly assist employees in accomplishing their goals and maintain effective controls throughout the organisation.

Conversely, 28.2% of the total respondents "disagreed" with the statement. This contradicts the work of Schroeder et al. (2008:544) who recommend that organisations should establish clear roles and responsibilities before embarking on any improvement project as a means of ensuring better control of activities throughout the project. It seems that organisations without clearly defined roles and responsibilities could create an environment of uncertainty where employees are unaware of what they need to accomplish, thus resulting in them not delivering the expected outcomes. It could possibly also result in inefficient working practices or may even result in workplace disputes.

The result in percentages for question 2.5 by the type of technique practiced is represented by Figure 24.



	Neither	Lean	Lean and Six Sigma	Total
Disagree	21.9	9.4	6.3	37.5
Neutral	3.1	6.3	9.4	18.8
Agree	12.5	12.5	18.8	43.8

Figure 24 – Type of technique practiced response for question 2.5

It can be gauged from Figure 24 that there is a general trend of "agreement" to this statement (43.8% of total respondents). Since this statement relates to improving employees' morale and reducing their confusion in terms of expectations and current performance, it can be related to the work of De Koning et al. (2008:41) who found that consistent feedback assists employees to enhance their performance and prevent repetition of errors. This finding is also aligned with Sim and Rogers (2009:46) who identified that appropriate feedback and communication played an essential role for continuous improvement initiatives.

For organisations that "disagreed" (37.5%) with the statement it could mean that these organisations restrict employees from realising their full potential and actual innate desires to make positive contributions in the workplace. This could perhaps be attributed to poor leadership in an organisation which correlates with the findings of Haikonen et al. (2004:374) who identified leadership as the main contributing factor to provide sufficient guidance and feedback to employees on their performance, especially in support of continuous improvement activities. It is the responsibility of the organisation's leadership to develop an environment in which it constantly provides information to employees and encourages the same from them (Comm and Mathaisel, 2005:136). The data in this section demonstrates that when feedback is correctly provided to employees it improves their job performance, accelerates learning to promote their professional and personal growth and meets their motivational needs.

4.5.3 COMMITMENT TO QUALITY

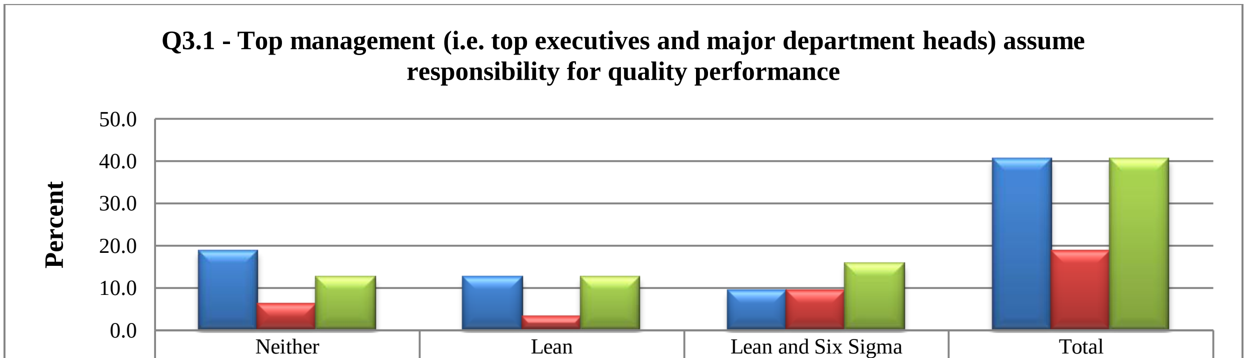
The questions in this section are centered on how the organisation integrates their management system and resources to improve their performance and commitment to quality. Some of the focus areas include management's leadership, the operator's ability to identify defects and the employee's responsibility in decision making. This type of commitment is required to deliver high quality products and services to customers. In responding to this section, the results of the associated questions are presented in Table 12.

Question 3 - Commitment to Quality	Mean	Gap	Communality	p-value for type of practice	Cronbach's Alpha
3.1) Top management (i.e. top executives and major department heads) assume responsibility for quality performance	2.8	-2.2	0.672	0.023	
3.2) Top management provides personal leadership for quality products and quality improvements	3.2	-1.8	0.800	0.161	
3.3) All employees are adequately trained on basic quality principles and statistical techniques	2.7	-2.3	0.696	0.007	
3.4) Quality data (error rates, defect rates, scrap, defects, cost of quality) are available throughout the plant	3.2	-1.8	0.638	0.088	
3.5) Quality data are used as tools to manage quality	2.8	-2.2	0.555	0.001	
3.6) The organisation faces up to problems immediately as they arise and makes effective decisions	3.3	-1.7	0.499	0.064	
Overall	3.0	-2.0	0.643		0.886

Table 12 – Results pertaining to commitment to quality

It is evident in Table 12 that questions 3.2, 3.4 and 3.6 score high in terms of "agreement" (mean values greater than 3). On the other hand, it is noted that the lowest scores in this section are represented by questions 3.1, 3.3 and 3.5 and will therefore be investigated in detail as these may be specific responses from the type of technique practiced. The variation in percentage also confirms these gaps. For question 3.2, the positive responses imply that management leadership and support ensures that senior management plays an active role in quality improvement. In relation to question 3.4, it can be inferred that quality and operational data is made available through various channels, such as notice boards, as a means of communicating the quality performance to the employees. Lastly, for question 3.6, the positive responses could mean that the organisations have effective measures in place to investigate problems as they occur. This concurs with Liker (2004:129) who is of the opinion that automatic devices such as "Autonomation" are commonly used in organisations to identify defects and stop production so that employees can fix the problem before product proceeds downstream. As highlighted in Table 12, 64% of the total variation is explained by the questionnaire model and the reliability value of 0.886 indicates high accuracy for this section. The Chi square values for questions 3.1, 3.3 and 3.5 supports the high gap scores. For these questions, the results may be attributed to organisations having different needs for improvement even though they operate in the same industry. An investigation of the questions with high gaps (Q3.1, Q3.3, and Q3.5) in this section by the type of technique practiced, follow.

The result in percentages for question 3.1 by the type of technique practiced is represented by Figure 25.

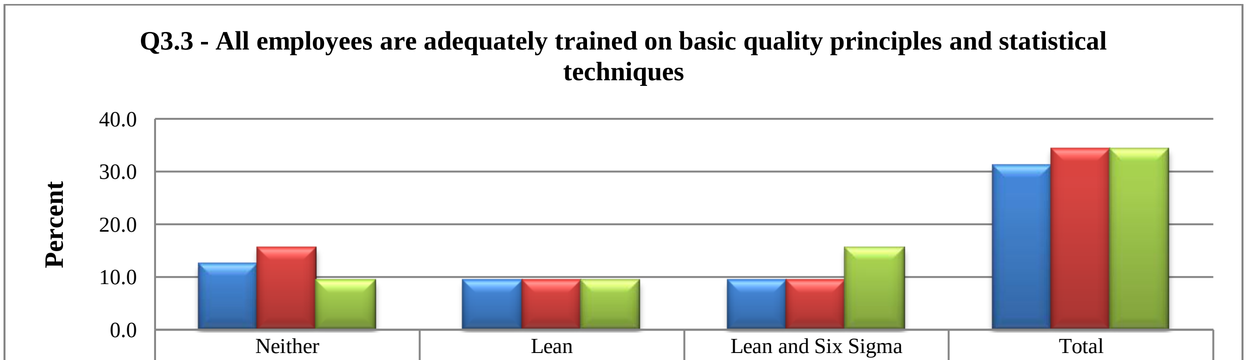


	Neither	Lean	Lean and Six Sigma	Total
Disagree	18.8	12.5	9.4	40.6
Neutral	6.3	3.1	9.4	18.8
Agree	12.5	12.5	15.6	40.6

Figure 25 – Type of technique practiced response for question 3.1

As presented in Figure 25, the first category shows a negative trend of "disagreement", the second category shows an equal split of "agreement" and "disagreement" and the third category shows a positive trend of "agreement". It is understandable that the responses of "uncertainty" could be interpreted as employees not being directly involved in quality improvement. The negative responses could mean that top management relies on their subordinates to assume the responsibility of quality performance. This finding is consistent with Lee and Peccei (2008:5) who articulate that the traditional organisational perspective required specialists to solve quality problems; however, this has changed over the years in best practice organisations where employees on the shop floor have taken the responsibility for quality improvement. On the other hand, the 40.6% of "agreement" implies that top management support for quality performance will improve customer and supplier relationship and workforce management. This corresponds with Zu et al. (2008:633) who state that when top management demonstrate their commitment to quality, it conveys the message to all employees that quality is critical to the business.

The result in percentages for question 3.3 by the type of technique practiced is represented by Figure 26.

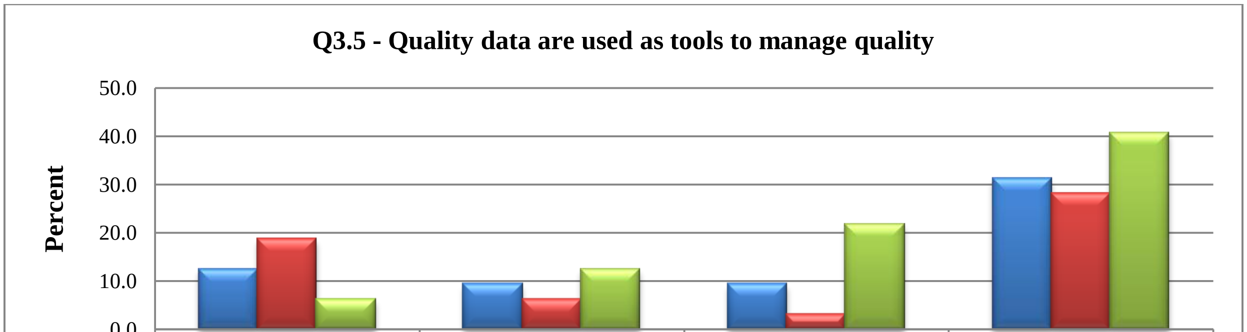


	Neither	Lean	Lean and Six Sigma	Total
Disagree	12.5	9.4	9.4	31.3
Neutral	15.6	9.4	9.4	34.4
Agree	9.4	9.4	15.6	34.4

Figure 26 – Type of technique practiced response for question 3.3

Although training provides employees with the key knowledge and skills to perform their functions, the results obtained in Figure 26 reveal similar responses of “agreement” (34.4%), “neutral” (34.4%) and “disagreement” (31.3%) from the total sample. The negative and neutral responses could be related to organisations that do not use statistical techniques or do not see the potential benefits of statistical tools. This correlates with Thomas et al. (2009:116-117) who contend that organisations generally have insufficient theoretical knowledge to see the potential benefits of statistical tools. However, for organisations that practice Lean and Six Sigma together, the high level of “agreement” (15.6%) confirms that statistical techniques are an essential requirement for Six Sigma. This result aligns with Evans (2008:269-270) who claims that the statistical techniques of Six Sigma requires advanced training and the expertise of specialists as it cannot be embraced by the average employee on the shop floor. On the other hand, the positive results of “agreement” (34.4%) could be reflecting the responses related to training of employees on basic quality principles. This means that organisations need to develop structured training programs for employees on basic quality principles so that it can build their technical skills and business competencies to meet the varying and challenging needs of the organisation.

The result in percentages for question 3.5 by the type of technique practiced is represented by Figure 27.



	Neither	Lean	Lean and Six Sigma	Total
Disagree	12.5	9.4	9.4	31.3
Neutral	18.8	6.3	3.1	28.1
Agree	6.3	12.5	21.9	40.6

Figure 27 – Type of technique practiced response for question 3.5

It can be observed in Figure 27 that the responses from organisations which practice neither technique reveal a high level of "disagreement" and "uncertainty" (31.3% in total) for this statement. In retrospect, therefore, it would appear that these organisations may not have formal quality systems in place to manage quality. This result confirms that organisations without formal quality systems do not see the benefit of maintaining quality data. This contradicts the findings of Zu et al. (2008:636) who maintain that quality information is essential to provide accurate and timely information for product quality and process performance. The highest content of "agreement" is within organisations that have improvement systems in place (34.4% of the 40.7%). This implies that they use reliable and accurate data for problem solving and also retain high quality information that can serve as a foundation for effective business decisions. This result coincides with Haikonen et al. (2004:370) who advise that effective business decisions can be made based on reliable and accurate data obtained during product and process improvements. Therefore, from an operative point of view, adopting the approach of maintaining quality data to manage quality practices will strengthen employee involvement in the improvement process as they will have sufficient information on hand to investigate the best possible solution.

4.5.4 PRODUCTION CONTROL

The essence of this section is to investigate the control mechanisms organisations employ in their production environment. It links questions related to the Lean tools and employee participation in response to evaluating the effectiveness within the organisation. The purpose of the Lean tools is to create value for customers with fewer resources (Lean institute). The overall mean scores, gaps, p-values and Cronbach's Alpha for each of the 10 questions representing this section are illustrated in Table 13.

Question 4 - Production Control	Mean	Gap	Communality	p-value for type of practice	Cronbach's Alpha
4.1) We use a pull production system in our manufacturing process	2.6	-2.4	0.856	0.305	
4.2) Single piece flow of material is maintained between processes	2.9	-2.1	0.766	0.181	
4.3) We use Kanbans systems to signal for material requirements in each process	2.7	-2.3	0.861	0.145	
4.4) The factory layout is divided into manufacturing cells that encompass product families with similar processing requirements	2.8	-2.2	0.572	0.323	
4.5) The production schedule is directly linked with the rate of customer demand	2.8	-2.2	0.653	0.322	
4.6) We use the SMED technique to provide rapid change-over of tooling and fixtures	2.7	-2.3	0.605	0.435	
4.7) The seven forms of production waste (overproduction, waiting, transportation, processing, inventory, motion, defects) are identified and highlighted in our processes	3.7	-1.3	0.415	0.266	
4.8) We practice the 5S tool to ensure that the organisations shop floors are well organised, clean and safe	4.0	-1.0	0.531	0.120	
4.9) We have standard operating procedures for all processes	3.3	-1.7	0.762	0.101	
4.10) Production is stopped immediately for every abnormality	3.2	-1.8	0.711	0.298	
Overall	3.1	-1.9	0.673		0.903

Table 13 – Results pertaining to production control

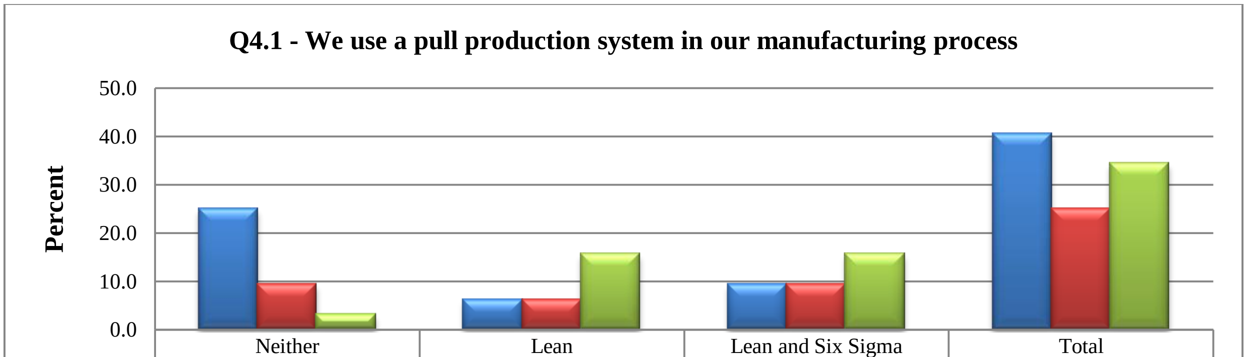
It can be concluded from Table 13 that questions 4.7, 4.8, 4.9 and 4.10 have been positively answered and show a stronger trend towards "agreement" (greater than 3). The positive responses for question 4.7 reveal that these organisations have methods in place to identify the common sources of waste in production. This is needed in a dynamic business environment. Rawabdeh (2005:803) indicates that it may be difficult to identify the various sources of waste owing to the numerous parameters and overlap that lies between the different processes. This also correlates with literature that the rationale of eliminating waste was to utilise the minimum amount of available resources that are required to add Value to the product or service while satisfying the customer's expectations (Morgan and Brenig-Jones, 2009:9; Thomas et al., 2009:114; Gupta, 2005:16).

In response to question 4.8, it could mean that the "5S" tool is correctly used in the organisations to maintain a clean and organised work environment. These results are consistent with the views of Worley and Doolen (2006:230) who claim that the 5S approach is based on the philosophy that a clean and organised workplace leads to greater willingness among employees to perform activities correctly. Since the primary aim of maintaining a clean organisation can lay the foundation for improvement opportunities, the resulting analysis from the proportion of positive responses is similar to the findings of Naslund (2008:275) who posit that the 5S methodology builds a culture into the organisation which eases the implementation of other improvement techniques. This would strengthen the employees' pride in performing their tasks and create a pleasant working environment that leads to improved employee attitude.

In terms of question 4.9, the positive responses reveal that the organisations have standard operating methods for their processes which make it easy for employees to perform their tasks consistently. This correlates with Morgan and Brenig-Jones (2009:12) who contend that standardised work methods seek to reduce variation in the way an employee performs a task that has been prescribed for a specific process. They advise that standardised work methods enable an organisation to gain more flexibility and uniformity for each process and assist the employees to consistently produce the same level of quality. This means that the sequence of job elements are arranged in such a way that it can be repeated by another employee and it facilitates ease for training new employees to perform a task. Lastly, for question 4.10, the positive responses could be reflecting the perceptions of empowering employees to stop production for every abnormality.

Beyond the above positive factors that seem to facilitate good production control, the negative responses for questions 4.1, 4.2, 4.3, 4.4, 4.5, and 4.6 also show that there are factors that inhibit the process. The high Chi square values in this section indicates divergence in the scoring pattern. This could mean that participants that practice the Lean technique share different views per question. The spread of the scoring patterns can be seen in the gap frequency tables. On closer examination, questions 4.7 and 4.8 indicate an approximate 3:1 ratio of “agreement” to “disagreement”. However, this may be technique specific. As can be seen in Table 13, 67% of the variation for all questions is explained by the questionnaire model. The overall reliability score of 0.903 highlights the accuracy of this section. An investigation of the gaps identified for questions 4.1, 4.2, 4.3, 4.4, 4.5, and 4.6 by technique practiced, follow.

The result in percentages for question 4.1 by the type of technique practiced is represented by Figure 28.

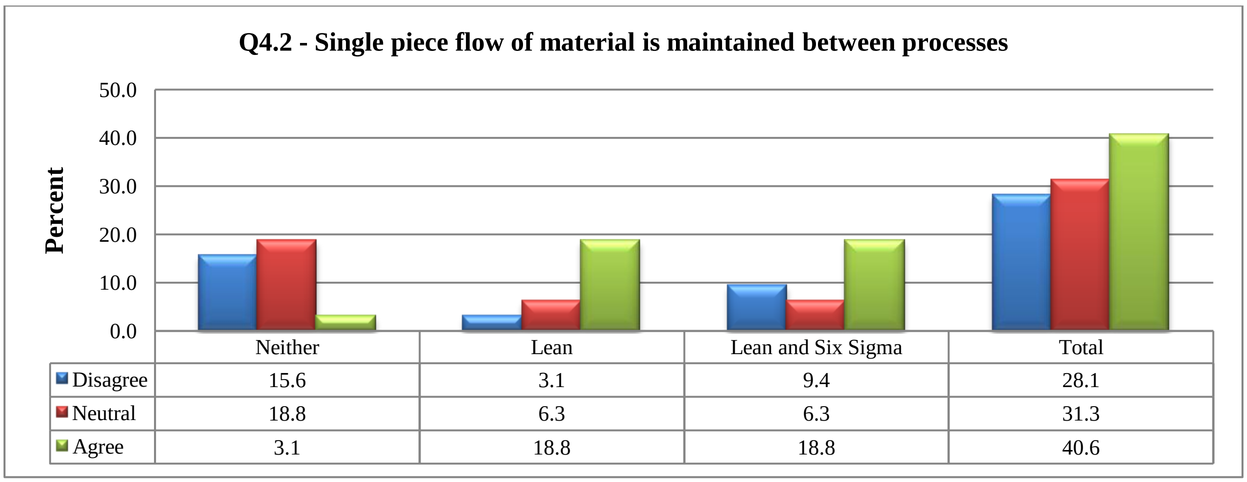


	Neither	Lean	Lean and Six Sigma	Total
Disagree	25.0	6.3	9.4	40.6
Neutral	9.4	6.3	9.4	25.0
Agree	3.1	15.6	15.6	34.4

Figure 28 – Type of technique practiced response for question 4.1

Figure 28 reveals a high amount of “disagreement” (40.6%) from the total responses to this statement. It is understandable that organisations which practice neither technique will have a high level of “disagreement” (25.0%) as the pull system is a Lean tool. The two categories which incorporate the Lean technique reflect the strongest sentiment of “agreement”. These positive results seem to facilitate that Lean organisations require minimum stock levels throughout the supply chain, which is aligned with the suggestion that the Pull system was created to prevent an organisation from manufacturing products in advance and storing unnecessary stock (De Koning et al., 2008:5; Schonberger, 2007:412; Andersson et al., 2006:288; Santos et al., 2006:174; Mathaisel, 2005:630; Arnheiter and Maleyeff, 2005:9). This means that the Pull system controls the flow of resources in a production process by manufacturing new products only when downstream products have been consumed. Therefore, it can be interpreted that a well-functioning “pull system” should work in tandem with other Lean tools to manufacture products based on consumption rather than forecasting. For example, small production batch quantities are needed to ensure quality problems are detected before large batches of defective parts are produced. The findings reveal that although the organisations may have documented procedures on how to use the “pull system”; the employees who are the main drivers need to fully understand how the system works. This corresponds with Dahlgaard and Dahlgaard-Park (2006:274) who insist that an organisation needs to have profound knowledge about systems and manufacturing psychology to successfully implement and maintain the pull system. This could perhaps be one of the reasons for the high level of “disagreement” in this section.

The result in percentages for question 4.2 by the type of technique practiced is represented by Figure 29.

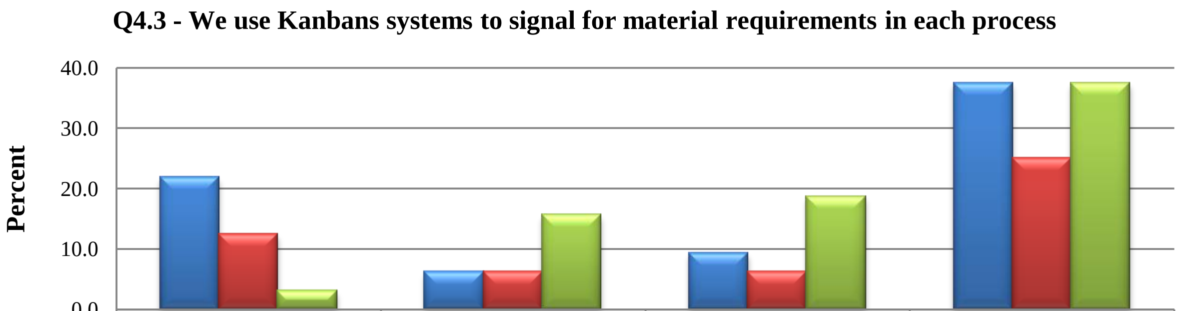


	Neither	Lean	Lean and Six Sigma	Total
Disagree	15.6	3.1	9.4	28.1
Neutral	18.8	6.3	6.3	31.3
Agree	3.1	18.8	18.8	40.6

Figure 29 – Type of technique practiced response for question 4.2

The results in Figure 29 indicate a high level of “agreement” (37.5 %) within oganisations that practice the Lean technique. Since single piece flow is conducive to organisations that are using the Lean technique for JIT production, the positive results align with literature that the JIT production system enables an organisation to manufacture and deliver products in smaller quantities and at reduced lead times to meet specific customer requirements (Morgan and Brenig-Jones, 2009:12; Liker, 2004:23). For organisations that “disagreed” with this statement, it could mean that they possibly manufacture products in excessive amounts and store unnecessarily. This contradicts what Rawabdeh (2005:801) claims: that JIT production ensures that all materials are actively in use as elements of work are in progress and never at rest collecting unnecessary storage costs. Another consideration from the negative responses is that organisations might find it difficult to implement JIT production because of the various requirements. For example Schroeder (2007:396) claims that JIT is closely related to Zero defects since the parts that arrive at each process needs to be fault free to achieve the sequential flow. This means that processes must be able to consistently produce good product or the single piece flow will not be achievable.

The result in percentages for question 4.3 by the type of technique practiced is represented by Figure 30.



	Neither	Lean	Lean and Six Sigma	Total
Disagree	21.9	6.3	9.4	37.5
Neutral	12.5	6.3	6.3	25.0
Agree	3.1	15.6	18.8	37.5

Figure 30 – Type of technique practiced response for question 4.3

As expected, the extent of "disagreement" depicted in Figure 30 for Kanban application (37.5% in total) is similar to those of the pull system and mirror each other closely. This makes sense, since a Kanban system is the classical signaling device for "pull" production as highlighted by the authors (Schroeder, 2007:399; Bhasin and Burcher, 2006:57; Papadopoulou and Ozbayrak, 2005:786). From the results presented in Figure 20, it is evident that two of the three categories that practice the Lean technique share the highest content of "agreement", which constitutes 34.4% of the total sample. Within all categories, there is some level of "uncertainty". One possible explanation could be that respondents do not understand the application of the Kanban concept. Another explanation is that organisations may not have common processes to use the Kanban system which is aligned with the views of Schroeder (2007:394) who concludes that Kanban systems are mainly used for repetitive manufacturing. These rankings are consistent with the objectives of maintaining the Lean technique because other tools such as "pull systems" and single piece flow are closely related to it. For example, Shah and Ward (2007:799) proclaim that the "pull system" facilitates JIT production through the use of Kanban cards which serves as a signal to start or stop production. This means that the Kanban concept can be classified as a visual control system which enhances the flow of components between processes and manages the quantity of WIP stock. The analysis of the combination of responses validates the strong negative feedback that the Kanban concept is not a popular tool within the sampled organisations.

The result in percentages for question 4.4 by the type of technique practiced is represented by Figure 31.

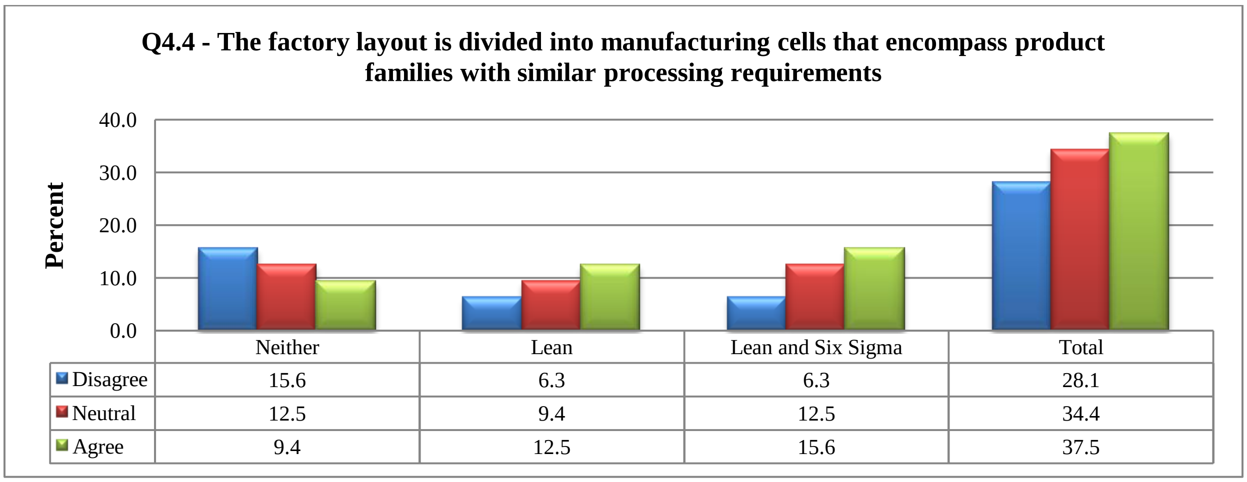
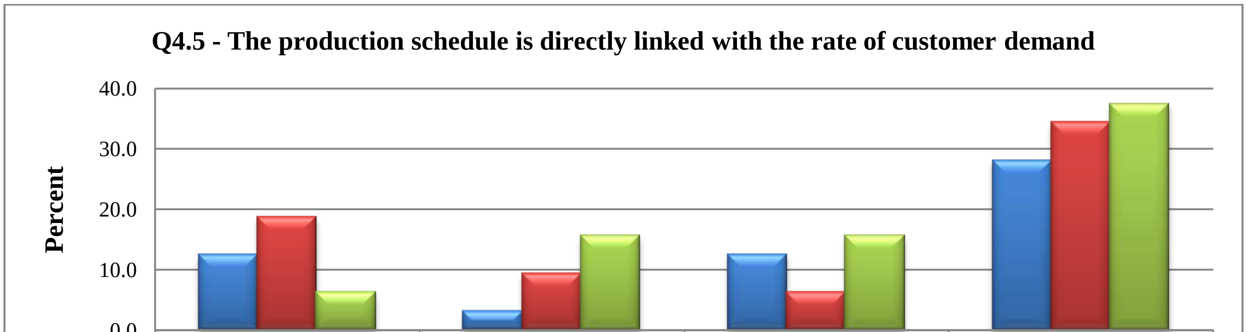


Figure 31 – Type of technique practiced response for question 4.4

It can be seen in Figure 31 that the two categories which practice the Lean technique have the majority of “agreement” (28.1%) to this statement which implies that they have manufacturing “cells” that could possibly be dedicated to a specific process, sub-assembly, or an entire product. This result aligns with Bhasin and Burcher (2006:57) that manufacturing “cells” group selected employees, machines and operational processes into an independent operational unit to manufacture a complete product from start to finish in a single process flow. It can be interpreted that if a process for manufacturing a product requires cutting, followed by stamping, and then drilling, then the manufacturing “cell” would arrange the equipment for performing these steps in the same order. For the high responses of “disagreement” and “uncertainty”, it could mean that the respondents have a wide variety of products and therefore find it difficult to implement this technique. Perhaps in these circumstances it can be suggested that manufacturing “cells” be created to produce sub-assemblies from similar equipment. This correlates with Shah and Ward (2007:799-800) who propose that products be grouped according to product families and equipment be laid out in the sequence of the manufacturing “cells”. This means that the manufacturing “cells” should focus on a low range of similar products.

The result in percentages for question 4.5 by the type of technique practiced is represented by Figure 32.



	Neither	Lean	Lean and Six Sigma	Total
Disagree	12.5	3.1	12.5	28.1
Neutral	18.8	9.4	6.3	34.4
Agree	6.3	15.6	15.6	37.5

Figure 32 – Type of technique practiced response for question 4.5

The result in Figure 32 demonstrates a high consensus of “agreement” (37.5% in total) among the three categories. The high level of uncertainty (34.4%) is understandable since the majority of the respondents are not directly involved in production. The organisations which “disagreed” with this statement implies that they probably find it difficult to accurately forecast customer demands. This can be supported by Liker (2004:116-117) who documents that since customers do not purchase products in a sequence it is difficult to predict their requirements and manufacture products accordingly. The majority of “agreement” within the organisations that practice Lean validates that their production schedule is consistently linked with the rate of customer demand. The organisations incorporate the total volume of customer orders for a predefined period and level them out so that the same quantity and variety of products are manufactured each day. This concurs with Emiliani and Stec (2005:373) who advise that production leveling assists an organisation to manufacture products at a constant and predictable rate. The resulting outcome from these findings is that production leveling can be used to bring stability to a manufacturing process in terms of customer requirements and production volumes.

The result in percentages for question 4.6 by the type of technique practiced is represented by Figure 33.

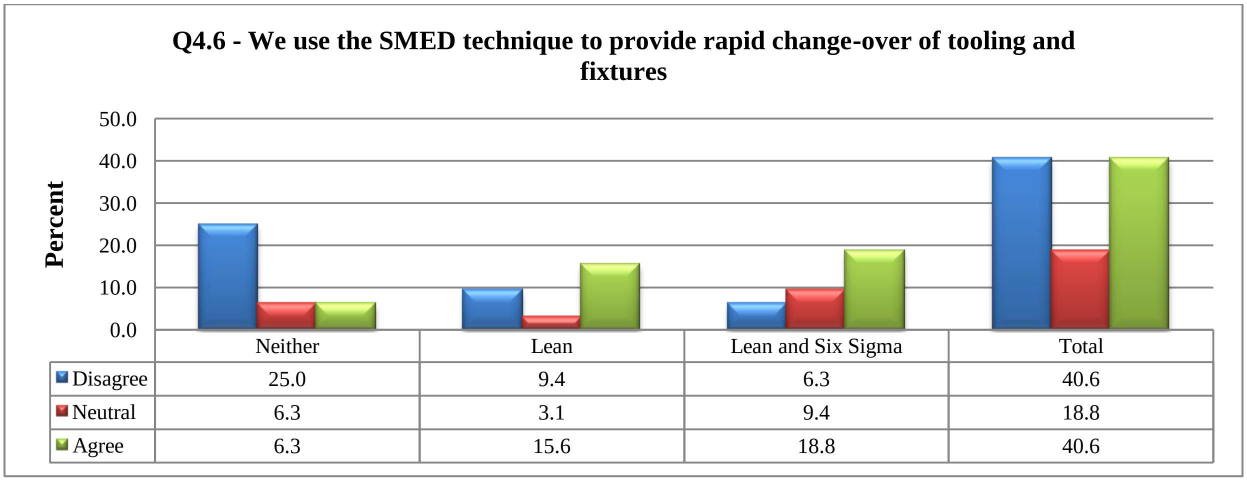


Figure 33 – Type of technique practiced response for question 4.6

Figure 33 reveals that the responses of "agreement" (40.6%) and "disagreement" (40.6%) are evenly split for this statement. When the data is evaluated by the type of practice it is noticed that organisations which practice neither technique have the highest amount of "disagreement" (25.0%) in contrast to organisations that practice the Lean technique. This result is conclusive since the SMED technique is related to Lean. For the respondents who "disagreed", it can be interpreted that their organisations do not see the benefit of reducing machine set up times during changeover in production. Since there are no restrictions for implementing the SMED technique, the findings of "disagreement" contradicts the view of Santos et al. (2006:140-145) who claim that it is possible to achieve effective machine changeover without costly investments since the SMED technique seeks to eliminate the use of screws and nuts as the fixing elements. In addition, the SMED technique focuses on converting internal setups into external ones so that these can be done while the machine is in operation and thereby reduces the set up time significantly when the machine stops. Although there is a marginal positive difference in "agreement" between the three categories, it is evident that the majority of these responses are within organisations that practice the Lean technique. This may be due to Lean striving for a smooth flow of activities between processes through the rapid changeover of tooling and fixtures. The result correlates with De Koning et al. (2008:4) who advise that the set-up time reduction seeks to increase the flexibility of production and optimises the utilisation of the production resources by reducing machine downtime.

4.5.5 PROCESS IMPROVEMENT

The purpose of process improvement is to optimise existing processes to meet higher performance levels of productivity and quality. It can be classified as an ongoing practice within organisations. Closely related to process improvement is the concept of Six Sigma which is to remove variation from processes and strive to manufacture defect free products. Therefore, this section incorporates tools associated with Six Sigma to measure the level of improvements sustained within the organisations. The statistical scores for each of the nine questions representing process improvement are illustrated in Table 14.

Question 5 - Process Improvement	Mean	Gap	Communality	p-value for type of practice	Cronbach's Alpha
5.1) "Poke-Yoke" devices are used in our organisation to minimize the chances of errors	2.7	-2.3	0.579	0.281	
5.2) Clear process instructions are given to employees	3.4	-1.6	0.661	0.015	
5.3) All equipment and processes on the shop floor are under statistical process control	2.6	-2.4	0.735	0.024	
5.4) Measures are in place to assess process performance and identify possible improvements projects	2.7	-2.3	0.823	0.017	
5.5) All improvement projects are structured and undertaken systematically	2.7	-2.3	0.524	0.000	
5.6) There is an appropriate infrastructure of improvement specialists in the organisation	3.2	-1.8	0.684	0.015	
5.7) All significant process improvement decisions are based on facts that are gathered from statistical data	3.2	-1.8	0.624	0.084	
5.8) The value stream is continuously evaluated and monitored for improvement opportunities	2.8	-2.2	0.765	0.002	
5.9) All processes are continuously questioned if it is adding value	2.7	-2.3	0.714	0.011	
Overall	2.9	-2.1	0.679		0.885

Table 14 – Results pertaining to process improvement

From Table 14, it is evident that questions 5.2, 5.6 and 5.7 have higher mean values and thus indicates that these responses are positively inclined. Question 5.2 reveals that employees have clear work instructions on how to perform their daily functions. These results are consistent with the views of Krichbaum (2008:2) who states that standardised work methods are used in an organisation to provide a detailed description to the employees on how to perform a series of predefined steps when operating a process. Since standardised work instructions represent the current best practices in organisations, it can be interpreted from the positive responses that employees have updated work instructions. This concurs with Montgomery (2010:59) who documented that work instructions generally reflect the latest design and engineering changes. It is important to acknowledge that work instructions should not be misinterpreted as a tool which can replace the skill and knowledge of the employees. This aligns with Liker (2004:13) who reports that labour advocates and humanists have always criticised assembly line employees as being oppressive and menial labour, thereby robbing employees of their mental faculties. Therefore, it is important that employees should clearly understand what is expected from management and management should also understand what is expected from employees.

For question 5.6, it can be inferred that an infrastructure of improvement specialists is needed in an organisation to support the growth of the business in the competitive and challenging market. These findings indicate that with the basic underpinnings of an infrastructure in place at the individual and team levels, it would leverage improvement projects between and across the different hierarchical levels in the organisation. In response to question 5.7, the management by fact concept enables effective decision making. This correlates with Haikonen et al. (2004:370) who claim that statistical methods generally assist the organisation to make decisions that are based on facts and figures during product and process improvements. Focusing on reducing the root causes of variation from a process and undertaking improvement tasks systematically ensures that the organisation does not generate inadequate conclusions which may have a negative impact on the customer (Nauhria et al., 2009:37; Schroeder et al. (2008:544). Therefore, to effectively manage by fact and reduce variation in an organisation, it can be suggested that the Six Sigma discipline should be ingrained in the culture context of the organisation to enable all employees to sustain the improvement efforts (McCarty and Fisher, 2007:188).

Aside from the positive responses to the questions discussed above, it is noted in Table 14 that questions 5.1, 5.3, 5.4, 5.5, 5.8 and 5.9 have the largest gaps in this section and will therefore be evaluated further by the type of technique practiced. The Chi square values for questions 5.1 and

5.7 indicate that there were no significant relationships as the questions related directly to the type of technique practiced. On the other hand, the significant relationships ($p<0.05$) established for the remainder of the questions indicate that process improvement priorities differ between organisations. It can be inferred from Table 14 that 68% of the variation for all questions is explained by the questionnaire model. This section also indicates a relatively high reliability with a score of 0.885. An investigation of questions 5.1, 5.3, 5.4, 5.5, 5.8 and 5.9 for the type of technique practiced, follows.

The result in percentages for question 5.1 by the type of technique practiced is represented by Figure 34.

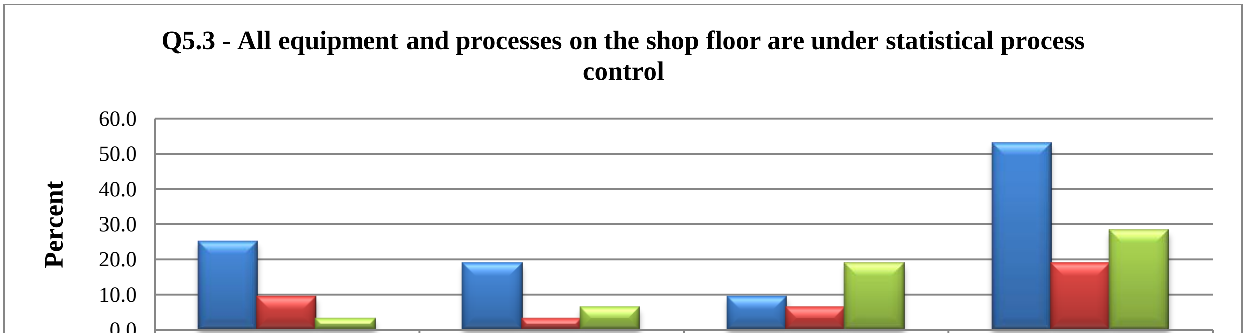
	Neither	Lean	Lean and Six Sigma	Total
Disagree	18.8	12.5	12.5	43.8
Neutral	15.6	3.1	3.1	21.9
Agree	3.1	12.5	18.8	34.4

Figure 34 – Type of technique practiced response for question 5.1

As demonstrated in Figure 34, there is a general trend of "disagreement" for this statement. Since the majority of "disagreement" stems from organisations that practice neither technique (18.8%), it can be interpreted that they do not understand these are creative devices designed to prevent defects moving from one process to the next and makes it nearly impossible for an operator to perform an error as highlighted by Chase et al. (2006:333). In addition, Santos et al. (2006:81) suggest that "Poke Yoke" devices should be designed in such a way that they are ingenious, simple and cheap. This means that these devices do not require a high amount of investment. In light of these findings, a suggestion would be for the organisations to consider adopting these devices through their processes as a means of predicting that a defect is about to occur and to provide a warning, or detection, that a defect has surfaced and to stop the process.

The majority of "agreement" (31.3%) is within the two categories that practice the Lean technique. Since Santos et al. (2006:76) and Chase et al. (2006:333) reveal that "Poke Yoke" devices are used to maintain Zero defects, the results concur with Schroeder (2007:396) that Zero defects are needed in Lean organisations to achieve the sequential flow. This means that "Poke Yoke" devices will prevent defects moving from one process to the next stage of production which correlates with literature that "Poke Yoke" devices are a form of source inspection that are commonly used to identify and eliminate defects in production (Morgan and Brenig-Jones, 2009:148; Evans, 2008:312-315; Schonberger, 2007:406; Liker, 2004:133). The advantage of this concept is that it presents opportunities for the employees' to pursue more creative and value adding activities in production rather than focusing on looking for defects.

The result in percentages for question 5.3 by the type of technique practiced is represented by Figure 35.



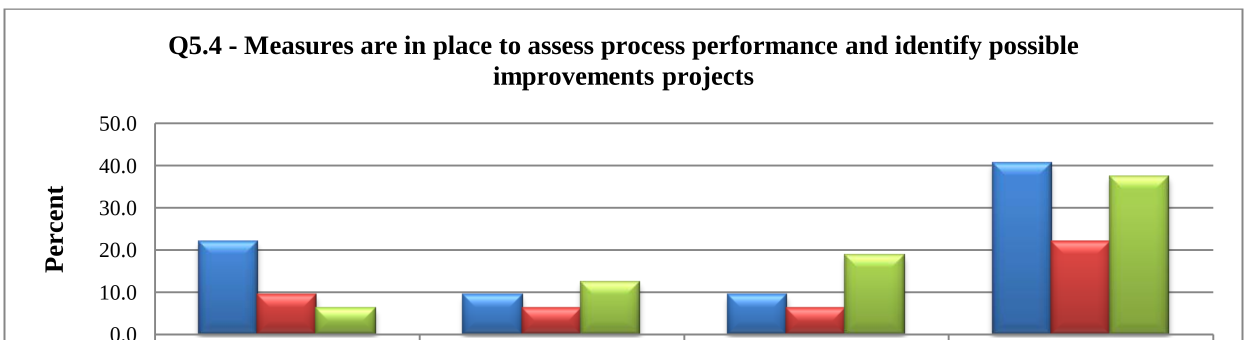
	Neither	Lean	Lean and Six Sigma	Total
Disagree	25.0	18.8	9.4	53.1
Neutral	9.4	3.1	6.3	18.8
Agree	3.1	6.3	18.8	28.1

Figure 35 – Type of technique practiced response for question 5.3

As observed in Figure 35, two categories (organisations that practice neither technique and organisations that practice Lean only) show a general trend of "disagreement" (43.8%) with the statement. The high responses of "disagreement" can be attributed to the advanced level of knowledge and selected improvement specialists that are required for working with statistics. The importance of these aspects is in accordance with claims from previous studies in the field that the selected hierarchy of process improvement specialists undergo intense training on intricate statistical and technical tools in order to work with Six Sigma improvement projects (Montgomery, 2010:62; Kumar et al., 2009:682; Montgomery and Woodall, 2008:332; Savolainen and Haikonen, 2007:9; Su et al., 2006:3; Andersson et al., 2006:287; Evans and

Lindsay, 2005:15; Haikonen et al., 2004:372; Goh and Xie, 2004:237). Since the sophisticated tools of Six Sigma cannot be embraced by the average employee on the shop floor, it can be interpreted that many organisations do not pursue the implementation of statistical process control in the context of Six Sigma. One possible explanation could be that they focus on traditional quality control such as conducting inspections to assure quality. In convergence the 18.8% of organisations that practice Lean and Six Sigma together claim that their processes are under statistical process control. Since the aim of statistical process control is to lay the foundation for improvement by removing variation, the resulting analysis from the proportion of positive responses highlights that these organisations see the benefit of statistical process control. This correlates with Nair et al. (2011:529), Montgomery (2010:59) and Montgomery and Woodall (2008:330) who claim that the objectives of statistical tools, along with other problem solving tools, serve as the technical foundation for quality control issues that underpin process improvement.

The result in percentages for question 5.4 by the type of technique practiced is represented by Figure 36.



	Neither	Lean	Lean and Six Sigma	Total
Disagree	21.9	9.4	9.4	40.6
Neutral	9.4	6.3	6.3	21.9
Agree	6.3	12.5	18.8	37.5

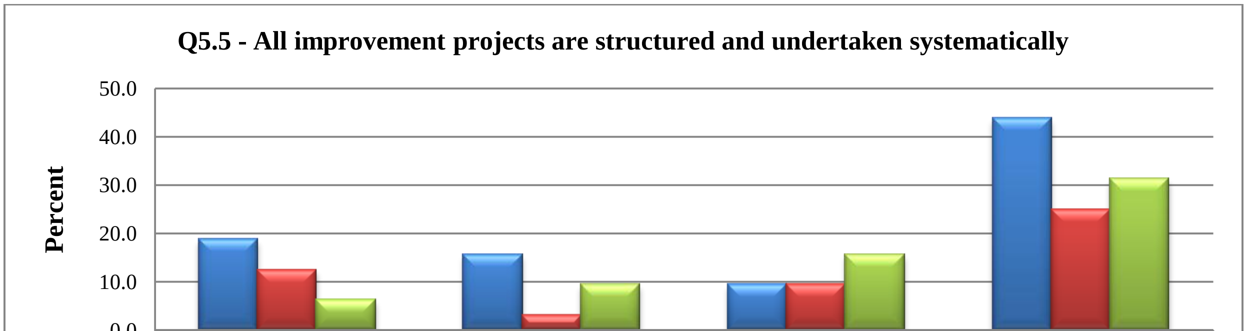
Figure 36 – Type of technique practiced response for question 5.4

It can be deduced from Figure 36 that there is an almost equal trend of “disagreement” (40.1%) and “agreement” (37.5%) to this statement. However, the highest sentiment of “disagreement” and “uncertainty” are within organisations that practice neither technique which points in the direction that they possibly do not have sufficient control mechanisms in place to monitor their processes. Although a small portion of organisations that practice Lean only (12.5%) agree with the statement, the majority of organisations that practice Lean and Six Sigma together (18.8%)

reflected the most positive responses for having measures in place to identify improvement projects. This could be the case since the key focus of Six Sigma is to identify improvement projects that affect the profit margins in an organisation.

This result shows alignment with the thinking that Six Sigma improvement projects are evaluated from a financial perspective using measures such as cost savings or increased revenue and non financial benefits such as the impact the project has on customers, the competitive advantage of the organisation and the optimisation effectiveness of the processes (Evans and Lindsay, 2005:66-69). It can be gathered from these findings that Six Sigma promotes the use of effective control mechanisms to identify significant improvement projects and to ensure that processes do not deviate from specification.

The result in percentages for question 5.5 by the type of technique practiced is represented by Figure 37.

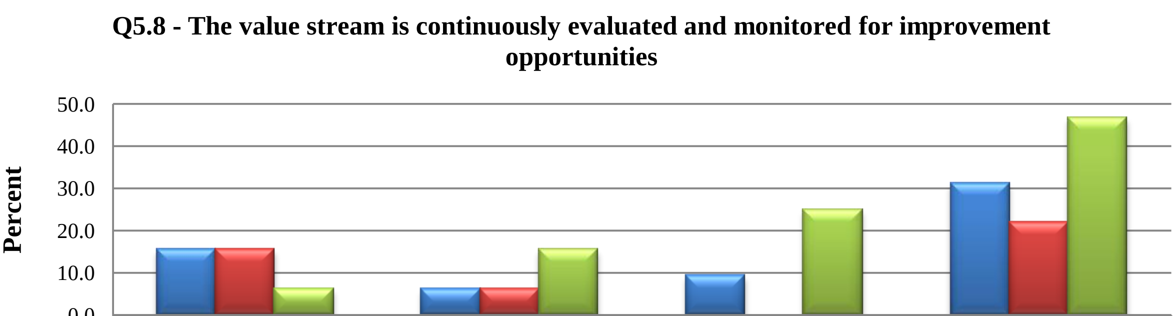


	Neither	Lean	Lean and Six Sigma	Total
Disagree	18.8	15.6	9.4	43.8
Neutral	12.5	3.1	9.4	25.0
Agree	6.3	9.4	15.6	31.3

Figure 37 – Type of technique practiced response for question 5.5

It is evident from Figure 37 that with the exception of organisations that practice Lean and Six Sigma together, the other two categories (40.6% in total) do not believe that improvement projects are structured and undertaken systematically. The results obtained could imply that organisations within the two categories of high "disagreement" undertake problem solving intuitively. One possible implication of intuitive problem solving is that employees may not collect sufficient descriptive data from the investigation area which could lead to the selection of solutions without sufficient consideration for alternatives. Also, the employees may consider the problem solved without proper testing of the solution's efficacy. These views are consistent with literature that the Lean technique does not have a systematic problem solving approach (Morgan and Brenig-Jones, 2009:36; Andersson et al., 2006:290; Su et al., 2006:5; Gupta, 2005:19). On the other hand, for organisations that practice Lean and Six Sigma together, the high response rate of 15.6% aligns with Starbird and Cavanagh (2011:20) who claim that Six Sigma integrates quality, root cause analysis and process improvement principles into a five step execution process to investigate improvement projects systematically. It is viewed as a closed loop process that eliminates unproductive steps and encourages creative thinking about a problem and its solution. It can be gathered from these findings that perhaps a more realistic middle path would be for organisations that scored low in this category to adopt a systematic problem solving approach such as Six Sigma to ensure all steps are reviewed; for example, collecting data or testing hypothesis before considering the solution.

The result in percentages for question 5.8 by the type of technique practiced is represented by Figure 38.

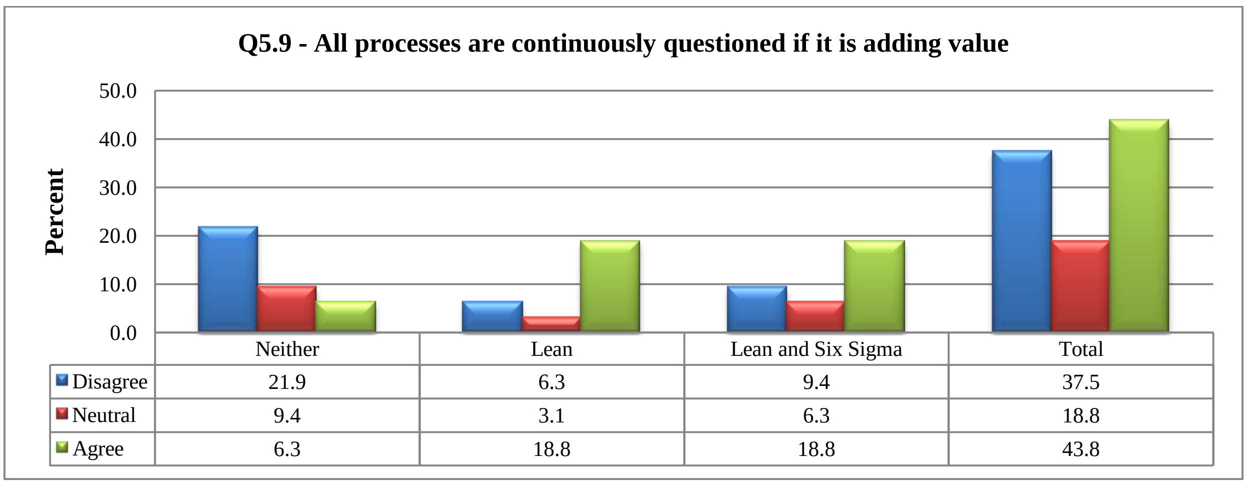


	Neither	Lean	Lean and Six Sigma	Total
Disagree	15.6	6.3	9.4	31.3
Neutral	15.6	6.3	0.0	21.9
Agree	6.3	15.6	25.0	46.9

Figure 38 – Type of technique practiced response for question 5.8

As highlighted in Figure 38, there is a high trend of "agreement" (46.9% of total sample) for this statement. Since the two categories of "agreement" incorporates the Lean technique, the result aligns with the objectives of Lean which is to continuously monitor and evaluate the value stream for improvement opportunities. The findings correlate with Schroeder (2007:409) and Chase et al. (2006:473) who claim that the value stream investigation represents material and information flow by identifying waste in the current production process and specifies methods for improving the entire value stream processes from the customers' perspective. The positive responses are also aligned with Lasa, Laburu and Vila (2008:50) who demonstrate how value stream mapping proved to be a suitable tool for redesigning production systems from their study conducted at a plastic manufacturing organisation. These results also support the notion that there is a causal relationship between continuous improvement and the identification of improvement opportunities in the value stream. For organisations that practice neither technique, the high level of disagreement elucidate that they do not consider the value stream as a useful tool to identify improvement opportunities. The negative response is in contrast to Bendell (2006:260) and Hines et al. (2006:873) who contend that a natural starting point for any business process improvement in an organisation is to investigate the value stream for improvement opportunities.

The result in percentages for question 5.9 by the type of technique practiced is represented by Figure 39.



	Neither	Lean	Lean and Six Sigma	Total
Disagree	21.9	6.3	9.4	37.5
Neutral	9.4	3.1	6.3	18.8
Agree	6.3	18.8	18.8	43.8

Figure 39 – Type of technique practiced response for question 5.9

As presented in Figure 39, 43.8% "agreed" with this statement while 37.5% "disagreed". The remaining 18.8% remained neutral as they were undecided. Out of the total responses that "agreed", 37.5% are within organisations that practice Lean. These positive responses seem to be in line with the findings from literature that the central focus of Lean is to create more value for customers by eliminating activities that do not add value to a product or service in an organisation (Starbird and Cavanagh, 2011:19; Karthi et al., 2011:310; Thomas et al., 2009:114; Pepper and Spedding, 2010:139). It is interesting to observe that majority of organisations that practice neither technique (21.9%) are struggling to identify if their processes add value. This finding reveals that these organisations should consider the work of Morgan and Brenig-Jones (2009:132) which explains that in order for a process step to be classified as adding value, it should meet the following criteria: is the step important to the customer, does the step either physically change the product or service in some way or is it an essential prerequisite for another step, and will the step perform its intended function correctly the first time. Perhaps it can be suggested that the organisation must understand what defines the customer's perception of value in order to create a path of sustainable competitive advantage due to the economic power from the producer to the customer.

4.5.6 EMPLOYEE INVOLVEMENT

This section evaluates the extent to which organisations encourage employees to participate in decision making. It should be noted that the best process improvement ideas reside in the front line employees and when goals are established through the interactions with upper management it serves as a motivation to encourage the employees' initiatives. Therefore, the questions that are structured around this section aim to evaluate the responses on teamwork, multitasking and training. The individual scores for each question and overall ratings for the section on employee involvement are presented in Table 15.

Question 6 - Employee Involvement	Mean	Gap	Communality	p-value for type of practice	Cronbach's Alpha
6.1) Shop floor employees participate in problem solving	2.8	-2.2	0.845	0.013	
6.2) Shop floor employees perform their own quality checks	2.8	-2.2	0.705	0.011	
6.3) Shop floor employees fix minor quality problems as they occur	3.2	-1.8	0.862	0.271	
6.4) Shop floor employees perform general maintenance of equipment	2.8	-2.2	0.599	0.034	
6.5) Employees are recognised for going the extra mile and making superior quality improvement	3.2	-1.8	0.906	0.015	
6.6) Employees are motivated to come up with improvement suggestions	2.8	-2.2	0.562	0.014	
6.7) Employees are rewarded for learning new skills	2.5	-2.5	0.698	0.043	
6.8) Sufficient cross functional training is provided to multi-skill employees	2.7	-2.3	0.653	0.002	
6.9) All employees are adequately trained to perform their functions	2.8	-2.2	0.641	0.015	
6.10) All employees are encouraged to assist across the different functions and work as a team	2.8	-2.2	0.647	0.012	
6.11) All employees are encouraged to challenge the way they work	3.3	-1.7	0.903	0.001	
6.12) Employees are encouraged to learn from mistakes so that we don't repeat them	3.3	-1.7	0.918	0.024	
Overall	2.9	-2.1	0.745		0.904

Table 15 – Results pertaining to employee involvement

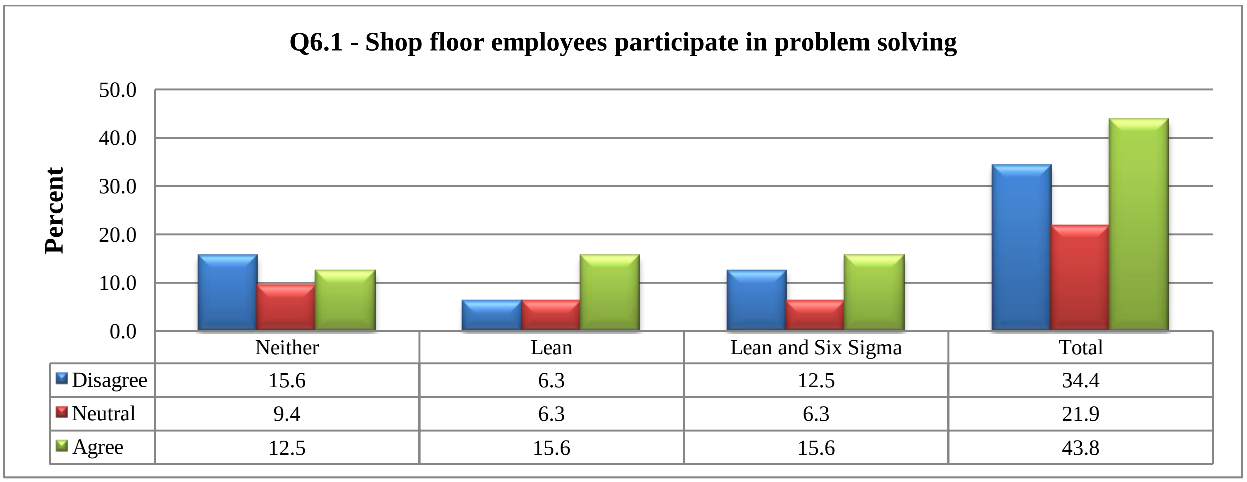
Given the emphasis on the people issues in the literature, the positive responses for questions 6.3, 6.5, 6.11 and 6.12 in Table 15 supplement the scoring pattern as these questions relate to the independence and contributions that are encouraged by organisations towards the employees. For question 6.3, the positive responses imply that employees fix minor quality problems as they occur and take the necessary corrective actions immediately, without interrupting the workflow. This is important to maintain a continuous workflow between processes with minimum or no interruptions. Since employees are the centre of an organisation, they should be trained to identify waste and solve quality problems at the source by repeatedly asking why the problem really occurs. This is aligned with Liker (2004:130) who suggests that solving quality problems at the source saves time and money because it identifies, fixes and eliminates defects. According to Olivella et al. (2008:800-802), employees should have a high degree of influence and a great body of knowledge to solve problems and develop improvements since they witness production events first hand.

The responses for question 6.5 indicate that employees are recognised for providing additional effort in their work. Recognising employees fairly and competitively based on superior performance motivates them to perform exceptional work. Employees usually strengthen their knowledge from previous encounters and continuous training accompanied with experience. Question 6.11 is aligned with Chase et al. (2006:479) who claims that when employees are challenged to use their initiative and creativity to experiment and learn more about their processes, it also challenges them to grow in their jobs by constantly solving problems. Being Lean means involving employees in the process and equipping them to challenge and improve their processes and the way they work. It can be surmised that the amount of waste that arises from human behaviour is probably greater than the waste that exists in a production environment. From an operative point of view, it is important to involve the employees in the process and provide them with the appropriate tools to enable them to challenge and improve their processes and the way they work. On the other hand, it can be interpreted that although employees may welcome challenges, there are those who may feel intimidated and prefer to remain with routine and safe methods.

The results for question 6.12 concurs with what Liker (2004:147) recommends, which is finding a balance between providing employees with rigid procedures to follow and allowing them the freedom to innovate and be creative to meet challenging targets such as quality improvement. This means that employees should learn from their mistakes and not feel threatened by management. A key implication barrier would be a proper management structure to support the employees so that they do not repeat a mistake.

The analysis of communality scores in Table 15 indicates that the questionnaire model explain approximately 75% of the variations for all questions while the reliability score of 0.904 for this section confirms that the instrument measured what it purports to measure. Further statistical analysis of Chi Square testing indicates significant relationships for all questions (p<0.05) except for question 6.3. The responses for question 6.3 could be interpreted as standard operating practice for employees to fix quality problems as they surface. The analysis of the negative questions (6.1, 6.2, 6.4, 6.6, 6.7, 6.8, 6.9 and 6.10) for the type of technique practiced, follow.

The result in percentages for question 6.1 by the type of technique practiced is represented by Figure 40.



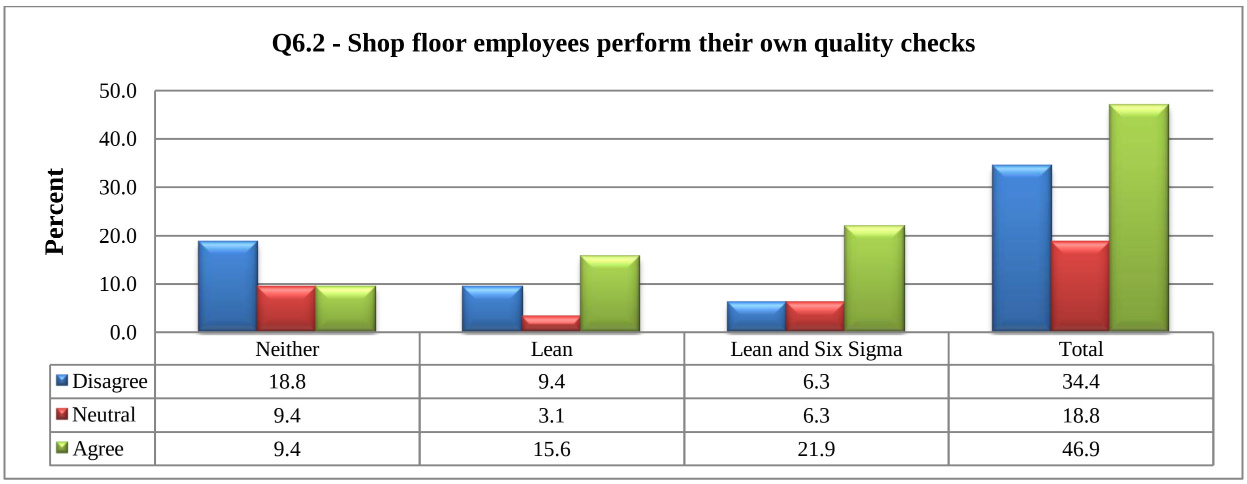
	Neither	Lean	Lean and Six Sigma	Total
Disagree	15.6	6.3	12.5	34.4
Neutral	9.4	6.3	6.3	21.9
Agree	12.5	15.6	15.6	43.8

Figure 40 – Type of technique practiced response for question 6.1

The results in Figure 40 depict a strong relationship of “agreement” within the three categories of responses which account for 43.7% of the total sample. It is reasonable that organisations which do not view shop floor employees as recognised experts of their own processes would indicate disagreement for this statement (34.4%). The negative responses could possibly be attributed to shop floor employees not having the technical knowledge of working with complex problems. In such circumstances, it can be suggested that shop floor employees be exposed to problem solving techniques that is directly related to their processes.

From Figure 32, the high level of “agreement” concurs with Liker (2004:33) that problem solving is most beneficial at the actual place where the problem occurred. This indicates that the leadership in these organisations encourages shop floor employees to participate in problem solving which correlates with Emiliani and Stec (2004:636) who contend that a leader who questions all processes and supports continuous improvement opportunities motivates employees to do so as well. Based on this idea, the shop floor employees will accept their suggested risks and enjoy work more because they are able to use their knowledge and skills in the workplace when they participate in problem solving. Along similar lines Khan, Bali and Wickramasinghe (2007:355) and Heizer and Render (2004:609) advise that employees' views should never be underestimated since they have firsthand knowledge and experience of processes on the shop floor. As a final note to this particular discussion, it can be interpreted that the positive results align with the work of Lee and Peccei (2008:9) who maintain that employees are likely to perform at their best to achieve quality goals set by management when they feel acknowledged and treated fairly for their contributions during problem solving.

The result in percentages for question 6.2 by the type of technique practiced is represented by Figure 41.



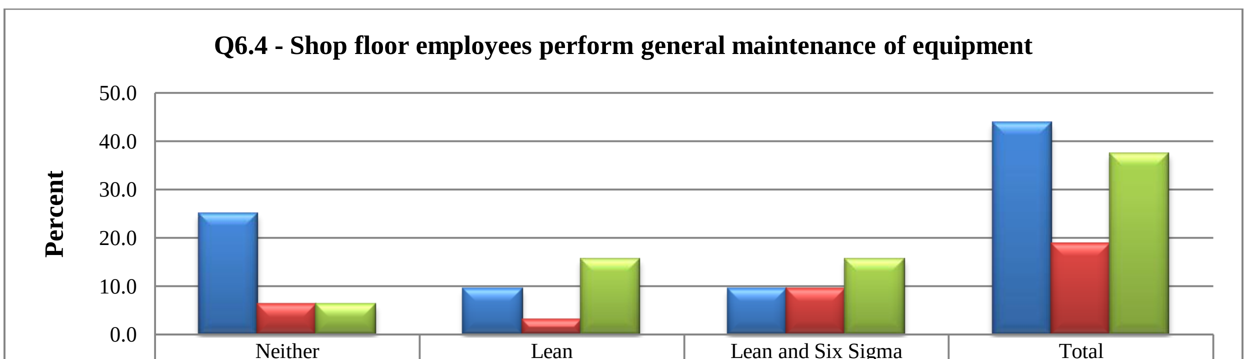
	Neither	Lean	Lean and Six Sigma	Total
Disagree	18.8	9.4	6.3	34.4
Neutral	9.4	3.1	6.3	18.8
Agree	9.4	15.6	21.9	46.9

Figure 41 – Type of technique practiced response for question 6.2

The analysis in Figure 41 reveals that the majority of organisations that practice neither technique show the highest contention of "disagreement" (18.8% of the total 37.5%) as compared to the other two categories. The analysis reveals that the shop floor employees within these organisations do not believe they are responsible for identifying defects. These results challenge the findings in literature of the various authors (Lee and Peccei, 2008:11; Chase et al., 2006:474; Liker, 2004:129) who contend that they should. On the other hand, the results of "disagreement" could verify the views of Santos et al. (2006:78) who are firm in their belief that operators are able to make unintentional errors during inspection and, therefore, would not like to be held responsible for performing quality checks.

The two categories which incorporate the Lean technique indicate that the shop floor employees perform their own quality checks. This correlates with Schroeder (2007:396) that parts which arrive at each process needs to be fault free to achieve the sequential flow in Lean. The findings are also aligned with Naslund (2008:275) and De Koning et al. (2008:5) where Lean requires smaller quantities of products at each process so that the shop floor employees can perform a quick quality check before moving their output to the next person in the proceeding process. If a defect is detected, the operator is expected to stop the process immediately and rectify the problem. It can be suggested from these findings that it is practical for employees to inspect their own work as it would assist them in identifying defects as they occur and prevent them from moving the defective product to the next process. However, under these circumstances, employees need to be trained on the quality standards that are required for each process. It is also important to empower employees to correct defects that occur at their workstations as a means of assuring quality.

The result in percentages for question 6.4 by the type of technique practiced is represented by Figure 42.



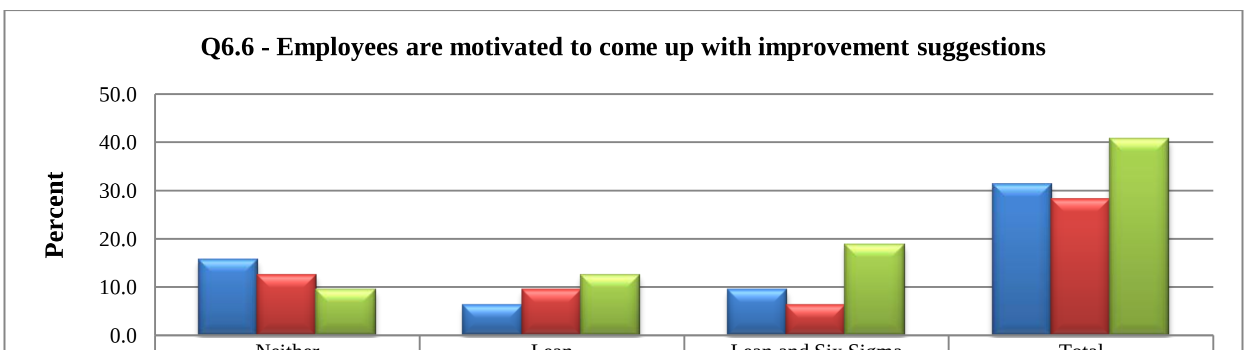
	Neither	Lean	Lean and Six Sigma	Total
Disagree	25.0	9.4	9.4	43.8
Neutral	6.3	3.1	9.4	18.8
Agree	6.3	15.6	15.6	37.5

Figure 42 – Type of technique practiced response for question 6.4

From the three categories represented in Figure 42, it is evident that organisations which practice the Lean technique (31.3% of total 37.5%) mainly “agree” with this statement. This finding can be related to the work of Schroeder (2007:403) who advises that multifunctional teams in Lean organisations do not assume productive tasks only but also indirect functions such as quality control and general maintenance of equipment. The result corresponds with Shah and Ward (2007:799) where shop floor employees in Lean organisations are required to perform general maintenance on equipment to ensure that the equipment is continuously operational to facilitate a smooth production flow and prevent disruptions in manufacturing. This means that the shop floor employees are included in maintenance and monitoring activities in order to prevent and provide warnings of equipment malfunctions. The central focus here is that it prepares the shop floor employees to be active partners with maintenance and engineering in improving equipment performance and reliability.

In terms of the respondents who "disagreed" with this statement (43.8%), this suggests that the organisations do not give shop floor employees a sense of responsibility and awareness for the equipment they use. Under these conditions, it could possibly result in misuse or abuse of the equipment. Since shop floor employees are accustomed to the equipment they work with, they are likely to identify when the equipment is in need of maintenance. Therefore, allocating responsibility to shop floor employees for maintaining their equipment could drastically reduce equipment failure as the users of the equipment would recognise potential failure conditions and take appropriate preventative actions before the actual functional failure takes place. Probably this would build a sense of responsibility, ownership and pride among shop floor employees and give them the knowledge and confidence to manage their own machines.

The result in percentages for question 6.6 by the type of technique practiced is represented by Figure 43.



	Neither	Lean	Lean and Six Sigma	Total
Disagree	15.6	6.3	9.4	31.3
Neutral	12.5	9.4	6.3	28.1
Agree	9.4	12.5	18.8	40.6

Figure 43 – Type of technique practiced response for question 6.6

It is observed from Figure 43 that all categories of responses have some level of "disagreement" with the statement. As a natural consequence of suggestions that are not implemented, it could validate the high sentiment of “disagreement” (31.3%), as indicated in Figure 43. The findings highlighted for “disagreement” contradict the views of Bhuiyan and Baghel (2005:766) who contend that employees are generally given explanations for suggestions that are rejected. Another possible interpretation could be that a suggestion scheme programme will have no motivational effect if there is no trust between employees and leaders. Ideally, the suggestion scheme programme should encourage employees’ participation in generating ideas for innovation and improvement.

For organisations which “agreed” with this statement (40.6%), the results suggest that the existing suggestion scheme programmes within these organisations are effective. These findings align with the views of Chase et al. (2006:327) who declare that the suggestion scheme programme is commonly used as a method of motivating employees to develop continuous improvement suggestions. Since the suggestion scheme programme usually provides intrinsic cash awards, the positive responses supports the findings of Olivella et al. (2008:807) and Bhuiyan and Baghel (2005:766) who claim that rewards are generally used as a motivator for participation. On the other hand, the results may contradict the views of Bicheno (2004:146) who is confident that the suggestion scheme programme is not always successful but that it should create a culture for continuous improvement. The overall results for this statement are similar to the findings of Lee and Peccei (2008:22) who studied two Korean organisations and concluded that rewards generally motivates employees as opposed to the job itself.

The result in percentages for question 6.7 by the type of technique practiced is represented by Figure 44.

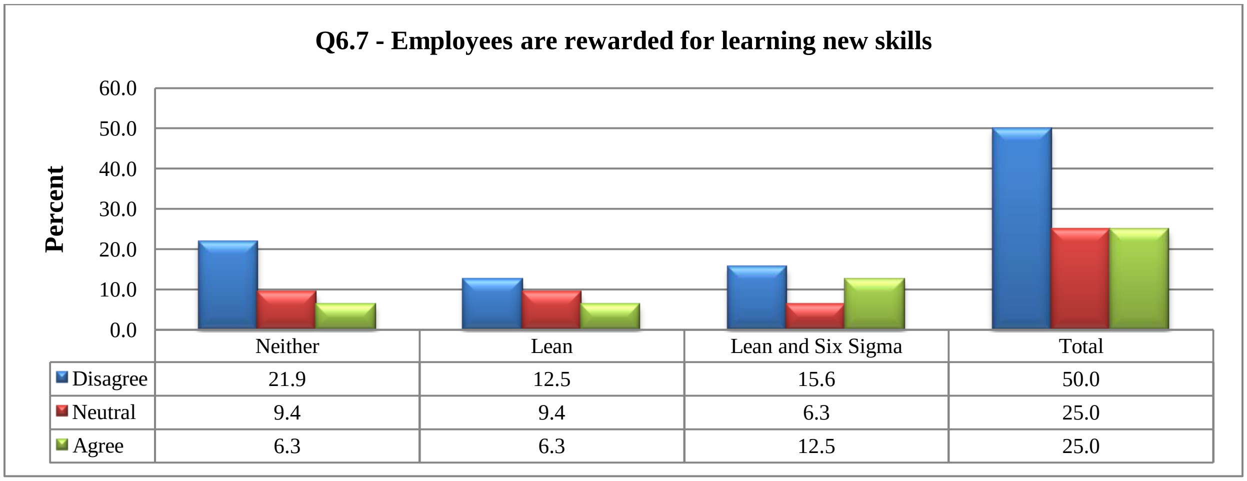
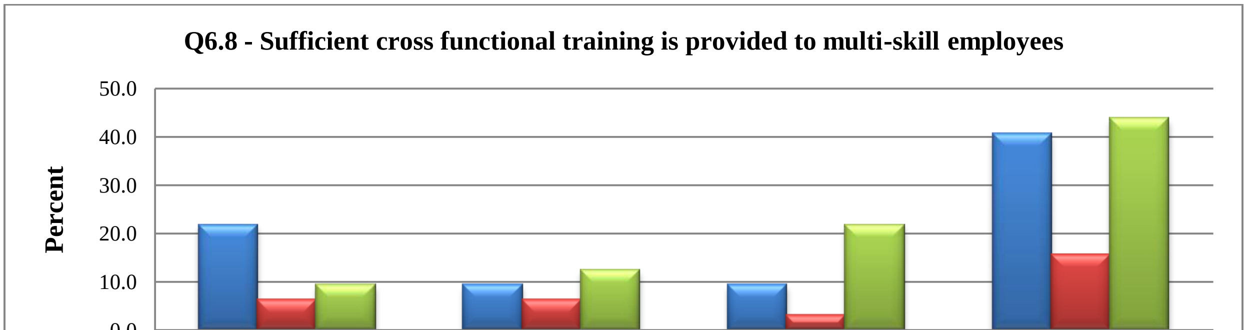


Figure 44 – Type of technique practiced response for question 6.7

As can be seen in Figure 44, 50% of the total responses “disagree” with the statement that employees are rewarded for learning new skills. Since this statement relates to the special attention given to the employees for their efforts towards quality improvement, it complements the scoring pattern of the respondents. For example, the respondents could have based their responses from their own personal experiences or could have misinterpreted this statement as a substitute for personnel actions, such as promotions or monetary benefits. Since recognition is a form of motivation, it can be interpreted from the high level of “disagreement” that the results contradict Comm and Mathaisel (2005:136) who suggest that when employees are given permission and tools to make changes in processes, they should also be appropriately recognised for their initiatives towards quality improvement.

The positive findings are consistent with Schroeder (2007:404) who believes that employees’ loyalty and commitment are significantly influenced by appraisal schemes. In general, employees tend to be skeptical and do not feel valued when they learn new skills and are not compensated by an appropriate remuneration system. Therefore, to remove the disillusionment that may occur as a result of training, organisations should attempt to make their training policy more structured so that employees can be rewarded adequately for learning new skills. The tendency of employees not being rewarded for learning new skills is in contradiction with Schroeder (2007:404) who believes that increased job responsibility should be compensated for accordingly. The interpretation of these findings suggests that human nature is such that employees will respond to whatever incentives and rewards are in place.

The result in percentages for question 6.8 by the type of technique practiced is represented by Figure 45.



	Neither	Lean	Lean and Six Sigma	Total
Disagree	21.9	9.4	9.4	40.6
Neutral	6.3	6.3	3.1	15.6
Agree	9.4	12.5	21.9	43.8

Figure 45 – Type of technique practiced response for question 6.8

As presented in Figure 45, there is an almost even split of responses for "agreement" (43.8%) and "disagreement" (40.6%) to this statement. The negative responses could imply that the employees are designated to perform only their specific job functions and are not able to multitask. This means that the employees do not perform work tasks outside the traditional boundaries of their original training and thus results in limited workforce flexibility in these organisations. The negative results contradict the views of Chase et al. (2006:435) who contend that multitasking employees and conducting frequent job rotation allows the organisation to make full use of employees' skills. One of the key benefits of multitasking employees, according to Comm (2005:64), is that it enables the organisation to reduce indirect departments. The results strongly suggest that operators should be exposed to frequent job rotation as a means of multitasking.

The responses of "agreement" are mainly linked with organisations that have improvement systems in place as represented in Figure 45. This means that employees in these organisations have training and skills in more than one area of a business, for example building a product and performing quality inspections. The positive results correlate with the authors (Olivella et al., 2008:803; Santos et al., 2006:68) who posit that multi-skilling allows employees to perform many different tasks. From an operational perspective, it can be concluded that multi-skilled employees do not feel threatened when new technology changes are required for production, as they would be accustomed to learning new skills and can consistently adapt to changes in production. In addition, multi-skilling employees would mean that the organisation has more flexibility to schedule and arrange employees to fill in for absent personnel or work in any area of the business that requires increased manpower.

The result in percentages for question 6.9 by the type of technique practiced is represented by Figure 46.

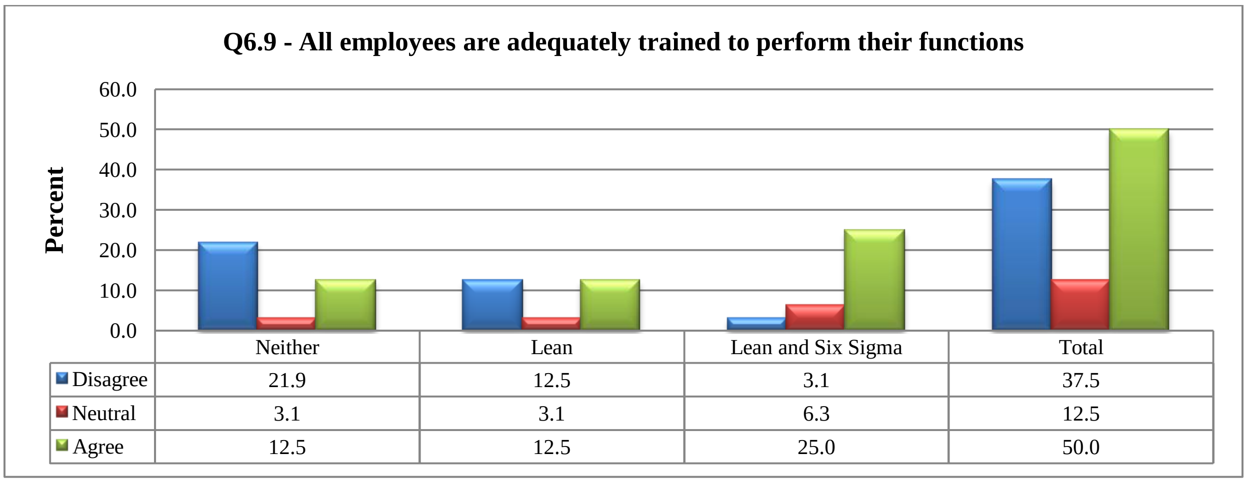
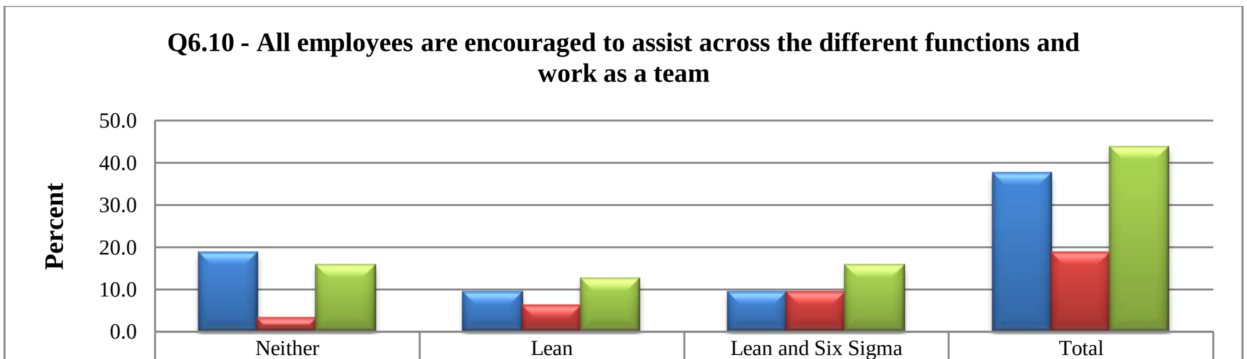


Figure 46 – Type of technique practiced response for question 6.9

Figure 46 shows that there is a high sentiment of “agreement” for this statement. Since the objective of training is to enhance the employee’s skills, the results indicate that 50% of the organisations have a high level of skilled employees who are adequately trained to perform their functions. This correlates with Comm and Mathaisel (2005:136) who articulate that as long as organisations provide proper training it allows employees to understand their process as well as the processes before and after in the product flow. This is also aligned with Comm (2005:69) who advocates that organisations are able to produce higher quality products with shorter lead times through proper training and the formation of quality improvement focus groups. Training should be well structured and documented on a relevant skills matrix. The skills matrix is a document that contains records of employees’ training and skills. In practice, Khan et al. (2007:356) claim that organisations should adhere to the skills matrix to ensure flexibility among employees.

For organisations that “disagreed” (37.5%) with this statement, the results contest what Santos et al. (2006:69) declare: that the ultimate goal of training programs is that it creates a comfortable learning environment which promotes the self-improvement of other employees. Therefore, Lee and Peccei (2008:5) advise that management should provide the necessary training for employees to secure a competitive advantage on the shop floor for achieving high quality work. It can be interpreted from the overall findings that employees usually strengthen their knowledge from previous encounters and continuous training accompanied with experience. Therefore, it can be suggested that organisations should provide the necessary training to ensure employees have sufficient and valuable knowledge they need to perform their tasks proficiently.

The result in percentages for question 6.10 by the type of technique practiced is represented by Figure 47.



	Neither	Lean	Lean and Six Sigma	Total
Disagree	18.8	9.4	9.4	37.5
Neutral	3.1	6.3	9.4	18.8
Agree	15.6	12.5	15.6	43.8

Figure 47 – Type of technique practiced response for question 6.10

As can be seen in Figure 47, the responses within the three categories "agree" that team work is effective within an organisation (43.8 percent of total sample). Another possible interpretation could be that the respondents view teamwork as an important competitive strategy which correlates with Evans and Lindsay (2005:15) that emphasis on teamwork focuses attention on building customer and supplier relationships and encourages the involvement of the total workforce. These results mirror those of other studies. For example, Starbird and Cavanagh (2011:140) found that teamwork promotes trust, support, respect and collaboration within the organisation. It can be argued that employees should also have an abundance of self confidence in their area of expertise to be successful in a team. The goal is for team members to demonstrate enthusiasm for the process and keep themselves and others motivated, especially as roadblocks and setbacks may appear.

The negative responses (37.5%) could imply that the respondents in these organisations do not see the benefits of working in teams. This result relates to the work of Liker (2004:185) who suggests that teams do not conduct value added work but individuals do. On this basis, it is understandable that individuals perform the actual work; however, the complexity and nature of some work makes it difficult for an individual to perform on their own and therefore requires different people with complementary skills to work together and accomplish the common goals of the organisation. It is the responsibility of the managers to formulate the designated teams, monitor the progress of the team's performance and develop the employees. Wallace (2004:803) contends that teamwork is influenced by a variety of factors and that it is imperative for employees to have the correct skills to form multifunctional teams. As such, the organisation must provide training for employees in developing the appropriate skills needed to work in teams. An important aspect of achieving effective teamwork involves team members being comfortable enough to admit when they are wrong without fear of embarrassment or punishment. It can be suggested that teamwork and support should be made available for all employees across the organisation and through an internal network. The positive views suggest that organisations should focus on team work rather than individuals working independently.

4.5.7 CUSTOMER FOCUS

This section investigates how customer needs and expectations are assessed. It associates questions related to customer involvement in improvement projects and how customer satisfaction is measured. The rated scores of responses for each of the questions representing customer focus are illustrated in Table 16.

Question 7 - Customer Focus	Mean	Gap	Communality	p-value for type of practice	Cronbach's Alpha
7.1) We frequently are in close contact with our customers	3.4	-1.6	0.659	0.286	
7.2) Customer surveys are used to elicit customer needs and "Voice Of Customer" information	2.7	-2.3	0.861	0.314	
7.3) Our employees know our customers and competitors	3.2	-1.8	0.762	0.918	
7.4) Our customers are directly involved in current and future product offerings	3.2	-1.8	0.778	0.144	
7.5) We use customer requirements as the basis for quality improvement	2.7	-2.3	0.676	0.286	
7.6) Our customers frequently share current and future demand information with our organisation	3.5	-1.5	0.640	0.122	
7.7) We continuously build customer confidence and create a clear understanding of our market	3.3	-1.7	0.826	0.095	
Overall	3.1	-1.9	0.743		0.876

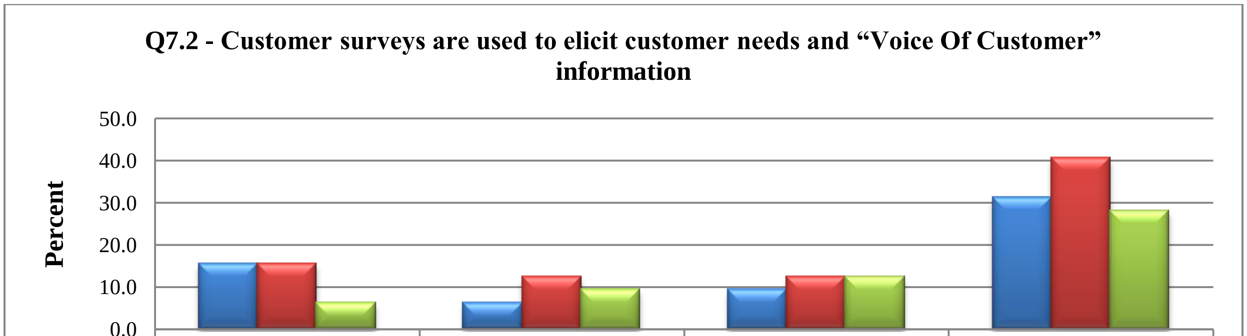
Table 16 – Results pertaining to customer focus

With the exception of questions 7.2 and 7.5, the remainder of the questions in Table 16 have strong positive responses (mean greater that 3) for this category. For question 7.1, the primary effect of keeping close relationships with customers is to create an atmosphere of trust and mutual understanding between the organisation and its customers to reflect the level of commitment the organisation has in meeting their needs, as suggested by Goh and Xie (2004:238) and Antony (2004:304). The positive responses for question 7.3 indicate that strategic information such as the organisations' market plans that revolve around customers and competitors is filtered to the employees. This finding concurs with Lee-Mortimer (2006:270) and Comm and Mathaisel (2005:137) that information in the form of a strategic type as well as operational type, which includes internal business processes and external outcomes, should be communicated to all employees. When employees know their customers, they are inspired to deliver exceptional customer experiences. It can be interpreted that organisations need to actively engage their employees with the customers to build loyalty, deepen relationships and gain access to insights that inspire future actions.

For question 7.4, the positive responses indicate that the organisations have developed mutually beneficial knowledge-sharing relationships with customers by talking to them about their future requirements and discussing how best to develop the products and services to meet their needs. This could mean that the customers' interaction with the organisation enables and encourages them to involve themselves as extensions of the organisation. In relation to question 7.6, when customers share their expectations with the organisation it prepares the organisation to cope with the existing market trends since the environment is dynamic and new problems and opportunities occur each day, as also highlighted by Hoerl and Gardner (2010:32-34). Question 7.7 was designed to gauge the importance that the organisations give to their customers and try to win their loyalty. The positive results indicate that organisations have increased customer satisfaction because they have a greater understanding of their requirements through feedback from customer communications. This creates a consistent customer experience through the integration of its products, processes and personal connections.

This section links questions of customer satisfaction in response to evaluating the effectiveness within the organisation. The overall communality value for all factors taken together explains 74% of the total variation for this section. In terms of accuracy, the Cronbach's Alpha value of 0.876 indicates high reliability for this section. The high Chi square values are reflective of the response type and could possibly mean that customers are the most important resource upon which the success of the organisation depends. Therefore, the organisations aim to anticipate and meet their needs and wants irrespective of the type of technique practiced. However, since there are large gaps prominent for questions 7.2 and 7.5 it will be investigated next by the type of technique practiced.

The result in percentages for question 7.2 by the type of technique practiced is represented by Figure 48.



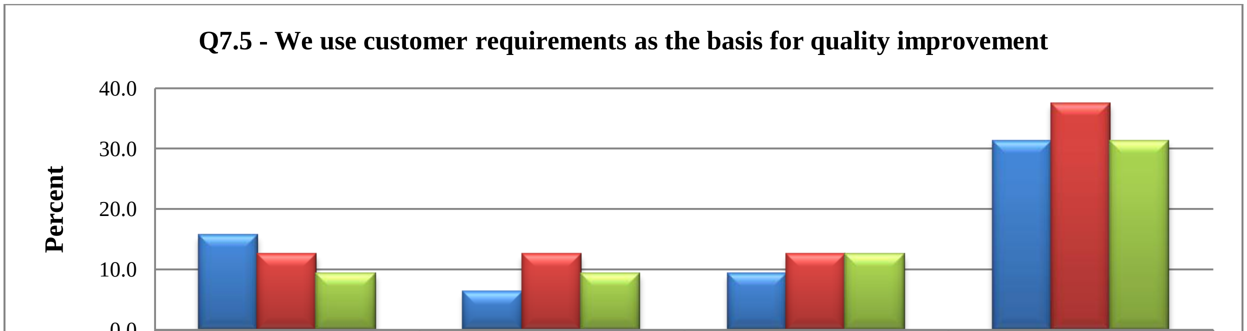
	Neither	Lean	Lean and Six Sigma	Total
Disagree	15.6	6.3	9.4	31.3
Neutral	15.6	12.5	12.5	40.6
Agree	6.3	9.4	12.5	28.1

Figure 48 – Type of technique practiced response for question 7.2

It is clear in Figure 48 that there is high degree of 'uncertainty" (40.6%) and an almost equal response of "disagreement" (31.3%) and "agreement" (28.1%) to this statement. Since this question relates to the marketing function that is used to measure and capture the VOC, it validates the high degree of uncertainty as there were not many respondents associated with this department from the participating organisations in this study. The majority of the positive responses are within the two categories that have improvement systems (21.9% of the 28.1%). This means that these organisations probably use proactive measures such as customer surveys as a means of obtaining information about their customer needs. Since exceeding customer expectations is an ever evolving process, the findings concur with Delgado et al. (2010:518) that the VOC describes what customers' require and their perceptions of how well the products or services meet their needs. The idea is to create an atmosphere of trust and mutual understanding between the organisation and its customers to reflect the level of commitment the organisation has in meeting their needs. It is anticipated that this interaction process provides a strategy to anticipate customer needs and for the organisation to respond to these needs before the competition does and it also assists the organisation to establish closer ties with the customers.

If organisations do not understand customer needs (31.3%), it could result in the customers becoming irate and taking their business elsewhere. This concurs with Goh and Xie (2004:238) and Antony (2004:304) who advise that the customers' CTQ characteristics can consistently fluctuate and will continuously change due to dynamic market demands. Since every customer has different needs, it can be interpreted that customers will only be satisfied when an organisation understands their individual needs, requirements and preferences. Therefore, organisations need to have effective measures in place to understand customer needs. By doing this, the organisations would be able to collect comprehensive, accurate and timely information about product and service quality which can be used to meet customer needs and to stay ahead of the competition. This would ensure that the objectives of the organisation are linked to customer needs and expectations.

The result in percentages for question 7.5 by the type of technique practiced is represented by Figure 49.



	Neither	Lean	Lean and Six Sigma	Total
Disagree	15.6	6.3	9.4	31.3
Neutral	12.5	12.5	12.5	37.5
Agree	9.4	9.4	12.5	31.3

Figure 49 – Type of technique practiced response for question 7.5

Figure 49 reveals that 31.3% disagreed, 37.5% were undecided and 31.3% agreed with the statement. The positive responses concur with Morgan and Brenig-Jones (2009:23-24) that the customers' CTQ characteristics provide the basis for the organisation to determine which process measures are critical, thereby assisting the organisation to understand what to provide and to evaluate how well it performs in achieving these critical requirements. This leads to the understanding that an organisation may not embark on any improvement initiative without prior consultation with the customer. Therefore, it is imperative to create an environment that is geared to locate, understand and satisfy the customers CTQ requirements as they impact a significant portion of an organisation. As such, it provides an opportunity for the customers to understand all processes that are involved in manufacturing their products and the associated problems that may exist within these processes.

The portion of "disagreement" could imply that if the customers CTQs are not investigated immediately, the relationship may become strained and they will be attracted to the competition.

In addition, customers' expectations generally grow daily and it is therefore important for the organisation to continually improve the quality of the products and services it has to offer. This correlates with Hoerl and Gardner (2010:32-34) who advise that creativity may be required to cope with the existing market trends since the environment is dynamic and new problems and opportunities occur each day. Understanding customer needs would help the organisation to define new market opportunities and drive innovation and revenue growth in every aspect of the business. This improves customer loyalty which leads to repeat business.

4.6 ANALYSIS OF THE TOOLS AND TECHNIQUES USED IN THE SAMPLE ORGANISATIONS

As evident in Figure 17, there is a wide spread in usage of improvement tools in the participating organisations. A closer analysis reveals that problem solving and Lean tools are commonly used among the organisations. These include 5S, control plans, check sheets, waste analysis, standardization, root-cause analyses, control charts, error proofing, Brainstorming, 5 Why analysis, histograms, Cause and effect diagram, trend charts, MSA, FMEA, Value added flowchart, process mapping and pareto charts. On the other hand, a notable observation is the lessened preference of statistical tools such as QFD, SIPOC, House of quality, CTQ Analysis, Fault tree analysis, scatter plot, ANOVA, Kano analysis, Hypothesis testing, DOE and regression analysis. The results strengthen the findings of Antony, Antony, Kumar and Cho (2007:301) who identified similar trends in UK organisations.

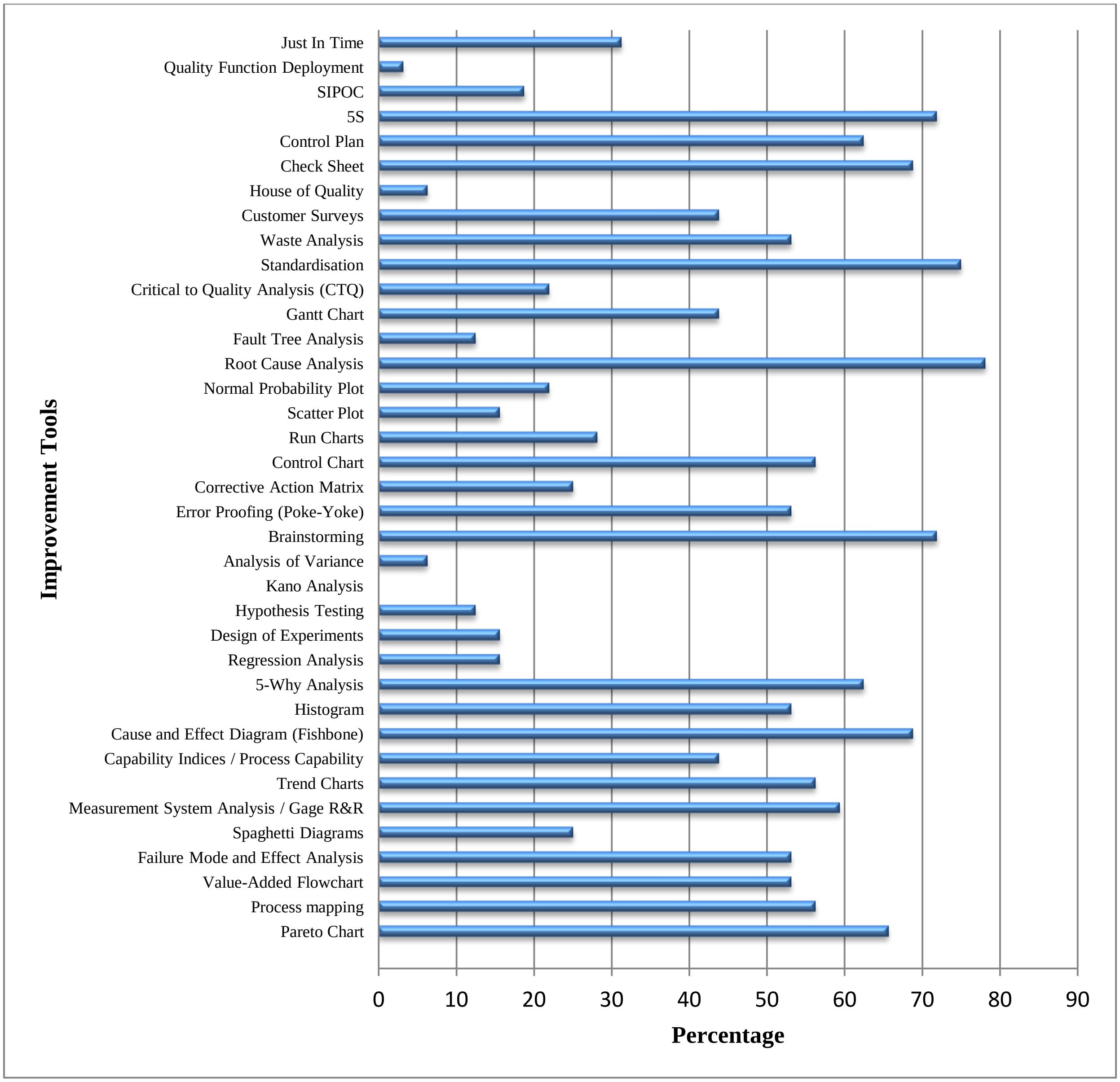


Figure 50 – Tools and techniques used in the sample organisations

It is reasonable to conclude from the results above that since problem solving and Lean tools offer visual representation of problems and are easier to use, they appeal more to the organisations than the sophisticated and complex statistical tools of Six Sigma. In addition, both techniques incorporate common tools such as brainstorming, standardisation and process mapping in its problem solving methodology (Salah et al. 2010:251; Antony and Desai, 2009:418). Another argument surfacing from Figure 50 is that only 30% of the respondents are using the JIT tool although 60% of the sample indicated that they practice the Lean technique. This could possibly mean that Lean organisations find it difficult to implement the JIT tool and therefore use other Lean tools such as 5S and Standardisation which are easier to implement.

4.7 SUMMARY OF THE CHAPTER

This chapter presented the statistical data of the empirical study and discussed how these results related to previous research findings and existing theory. The responses were analysed and interpreted to determine if the empirical study supports the research hypothesis. The analysis performed on organisations that practice the Lean technique as a standalone system revealed that there are inherent weaknesses in the system. It was established that, according to the respondents, these weaknesses showed a strong positive association with the strengths of the Six Sigma technique. Similar analysis was performed on organisations that practice the Six Sigma technique and the results demonstrated that the weaknesses of Six Sigma as a standalone system related to the strengths of the Lean technique. These results provide the evidence to conclude that Lean and Six Sigma have weaknesses as standalone systems and thus supports the hypothesis that there is a strong association between Lean and Six Sigma to work together to produce superior performance improvement. This correlates with literature that the integration of Lean and Six Sigma was favoured over the years within organisations that decided that Lean and Six Sigma work in unity rather than independently (Snee, 2010:10; De Koning et al., 2008:7; Su et al., 2006:2).

The results from section four of the questionnaire (Lean Six Sigma success factors) revealed that there is a statistically significant difference in the business performance levels between organisations that practiced Lean only, organisations that practiced Lean and Six Sigma together and organisations that practiced neither technique. It appears that organisations which have improvement systems in place showed better results on the business performance scale than organisations which have no improvement systems in place. This indicated that there is a large gap in terms of aligning the proposed success factors for the integrated Lean Six Sigma framework. The appropriate responses were quantitatively identified and the nature of these relationships and the differences were revealed. The results of this part of the survey identified 32 focus areas that required improvement and, therefore, only questions that had statistically significant relationships were discussed. These focus areas were critiqued in the context of their underlying strengths and how they can improve business results. The conclusion of this chapter reviewed the common tools that are currently used in the participating organisations. All of the aforementioned analyses are strongly tied to the context from which they are derived and provide the required information needed to develop the integrated Lean Six Sigma framework from a KZN perspective. Based on the analysis and presentation of the results obtained, the following chapter concludes this research and suggests recommendations and opportunities for further research.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 INTRODUCTION

This final chapter will present an overview of the investigation accomplished through the theoretical analysis and field wok of the study. It will combine the various aspects documented throughout the research project and design a Lean Six Sigma framework applicable to a KZN context, which was the primary objective of this study. The findings and conclusions will be based on theories studied to ascertain the contributions of integrating Lean and Six Sigma into a unified improvement technique to enhance manufacturing performance. The first part of this chapter summarises the theoretical and empirical investigations, followed by discussions pertaining to the achievement of the research objectives. Thereafter, the chapter describes the proposed Lean Six Sigma framework created by the researcher based on the data and analysis presented in this research. The limitations of the study, along with recommendations deduced from the investigation, are also presented in this chapter. The chapter ends with suggestions for future research opportunities and a final summary of the project.

5.2 SUMMARY OF THEORETICAL INVESTIGATION

It was established in chapter one that the integrated Lean Six Sigma technique is the latest generation business improvement tool that is evolving and has encapsulated the manufacturing world. It is derived from the joint application of Lean and Six Sigma that aims to target every type of opportunity for improvement in an organisation. Although Lean and Six Sigma evolved independently over time and have proven over the years to improve an organisations performance in terms of cost, quality, productivity and customer satisfaction, the first step of the theoretical study investigated what unique performance measures each technique offers the business world when adopted independently. By investigating the outcome of these independent performance measures, it created a clear understanding of each technique’s unique capability and provided an avenue to address the difficulties that organisations encountered when using them as standalone techniques. This understanding was required in order to perform an in-depth analysis between the gaps, similarities and differences that prevailed in literature between Lean and Six

Sigma; and it validated the contributing factors and rationale for combining them into an integrated business improvement tool.

The next step of the theoretical study used case studies from literature to explain the uniqueness and benefits obtained by organisations which have adopted the Lean Six Sigma technique. The information indicated at a glance what is new about this approach compared to other improvement techniques and suggested that it is a better choice to produce superior business performance in the global arena. Thereafter, an analysis was conducted on seven principles recommended by the authors for guiding the deployment of Lean Six Sigma (Starbird and Cavanagh, 2011:76; Snee, 2010:22; Morgan and Brenig-Jones, 2009:23-25; De Koning et al., 2008:7; Gupta, 2005:117-18). Since there was limited information regarding definitional and methodological issues of Lean and Six Sigma integration in literature (Thomas et al., 2009:113; Shah et al., 2008:6680; Bendell, 2006:255-259), an evaluation was performed on the critical success factors that should be considered when constructing a Lean Six Sigma framework. Therefore, based on the theoretical underpinning of Lean, Six Sigma and Lean Six Sigma investigated in chapter 2, a questionnaire was designed in measurable format to gather practical information from organisations within the DAC on the status of their existing business improvement programs and quality practices. The information was necessary to complete the transition from theory to practice with more critical analysis regarding the construction of a Lean Six Sigma framework from a KZN perspective.

5.3 SUMMARY OF EMPIRICAL STUDY

The empirical part of the study gathered information from the KZN business climate to design a Lean Six Sigma framework that would create many essential aspects of an idealised quality management system for improving organisational performance and becoming world class. This part of the study produced the results of the survey conducted in the DAC which was to investigate their existing business improvement techniques and quality practices. The first performance measure provided a closer insight into the status of independent Lean and Six Sigma operations in the sample organisations. Important constructs of evidence were extracted and examined with the theoretical background to support relationships between Lean and Six Sigma that affect cost, quality, productivity and customer satisfaction, and its impact on organisational performance. This part of the study demonstrated the strengths and weaknesses of independent Lean and Six Sigma operations from a KZN perspective and built on the literature regarding the encouragement of the integrated Lean Six Sigma technique.

The next part of the empirical study gathered practical information from the sample organisations on the recommended principles and critical success factors that were required for designing a Lean Six Sigma framework. This information was necessary to evaluate those aspects of the sample organisations that needed improvement, that is, where there is a gap between actual and ideal. This part of the study identified various improvement opportunities towards the sample organisations and revealed that critical success factors of quality initiatives are equal in importance, irrespective of the type of technique implemented by an organisation.

The final part of the empirical study extracted the common tools and techniques used in the sample organisations. A relationship was established between the common tools and performance levels of an organisation. All findings that had a statistically significant result throughout the section were compared to theory and discussed in detail. The study revealed that independent Lean or Six Sigma techniques are not ideal, but that a combination can provide practical and useful solutions of a structured approach to business and quality improvement based on the integration of Lean and Six Sigma techniques.

5.4 ACHIEVEMENT OF RESEARCH AIMS AND OBJECTIVES

In order to meet the main objective of this study which was based on the researcher's intention to design a Lean Six Sigma framework for manufacturing organisations in the KZN automotive sector, the following research question had to be asked: What is the consequence of integrating Lean and Six Sigma and will this combination produce superior business results? The results obtained in chapter 4 was critiqued with the theoretical investigation of chapter 2 to support the first two objectives of the study which was to investigate the performance levels of organisations that practice Lean and Six Sigma as standalone techniques. The empirical evidence indicated that although Lean and Six Sigma produced different performance outputs as standalone techniques, a significant relationship was established between the success factors and their impact on manufacturing performance.

The findings and relationship established above provided support to the third objective of this study which was to investigate the consequence of integrating Lean and Six Sigma to complement and reinforce each other. The validated results of the study indicated that despite the differences between these two techniques, there are many areas where Lean and Six Sigma share common ground and there are many compatible areas where the strengths of one technique complement the weaknesses of the other. The results, from a KZN perspective show proof that Lean and Six Sigma have limitations as standalone systems and therefore justify the need for uniting these techniques. Although it was noticeable that some organisations initially started off with the Lean technique and then implemented Six Sigma for additional improvement, the results indicated that they practiced them independently and did not realise that the synergy effect of the integrated Lean Six Sigma technique was more beneficial than operating each individual technique. This synergy effect can assist organisations to yield significantly better performance measures through the overlap among its various components. All areas identified for improvement opportunities highlight that additional work is necessary to enhance the current manufacturing processes in the sample organisations.

Apart from satisfying the three research objectives above, it created a clearer understanding of the topic and, together with the literature review and empirical analysis, it supported those factors that influence the suitability of integrating Lean and Six Sigma in the context of the KZN business environment. This information provided the guidance for designing the Lean Six Sigma framework set out in this study.

5.5 PROPOSED LEAN SIX SIGMA FRAMEWORK

Emerging from the theoretical underpinning of the literature review and analysis of the survey results, the researcher developed an integrated Lean Six Sigma framework for the KZN automotive sector as illustrated in Figure 51. Assistance in designing the framework was provided by key industry specialists and academics who have in depth knowledge on Lean and Six Sigma. The Lean Six Sigma framework adheres to the philosophy and principles of both Lean and Six Sigma.

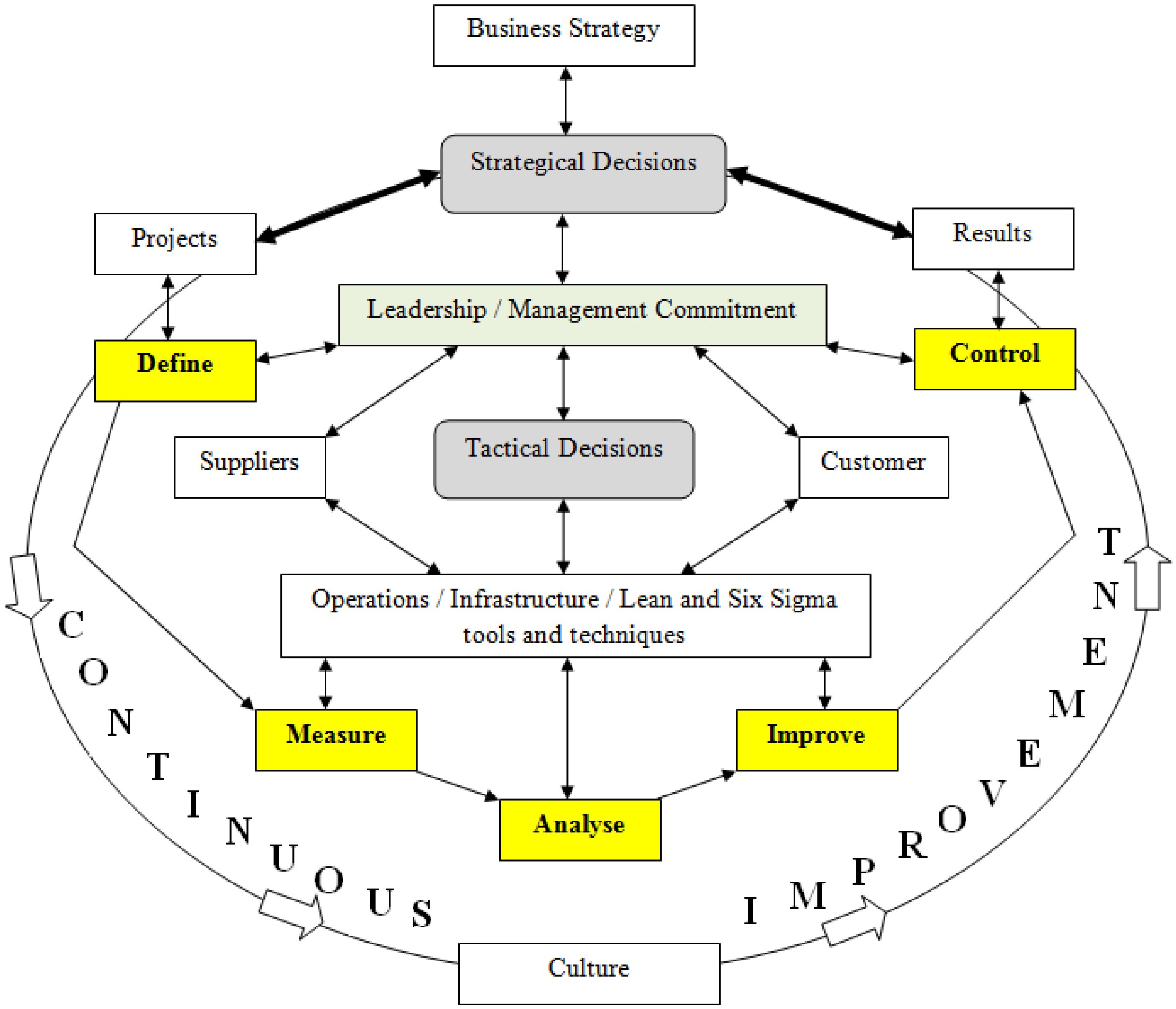


Figure 51 – Lean Six Sigma framework (devised by researcher)

As can be seen in Figure 51, the framework depicts how the strategic analysis provides the mechanism by which the continuous improvement strategy is adjusted in accordance with the corporate culture of the organisation. The framework starts with the organisation developing their strategic business objectives. Each strategic objective is then translated into suitable projects that will facilitate continuous improvement. The project selection process should not be based on short-sighted financial targets, but on the impact it has on strategic business objectives and goals, contribution to bottom-line performance and benefits to customers and stakeholders. The projects should be supported by the organisations leadership and management commitment. The projects are then handed over to the operational level, and it is followed through with the DMAIC cycle. This part of the framework is tactical as it aligns supplier commitment and customer satisfaction directly to the operational activities. The operational activities include the infrastructure and selection of the correct tools for each step of the DMAIC cycle as represented in Table 17.

Define	**Measure**	**Analyse**	**Improve**	**Control**
SIPOC	Check sheet	Cause and effect analysis	Analysis of variation	Process documentation checklist
Project charter	Measurement System Analysis	Brainstorming	Design of experiments	Control charts
VOC / QFD	Process Capability Assessment	Histogram	FMEA	Control plans
Customer surveys	Normal probability plot	Scatter diagram	Corrective action matrix	Poke Yoke
House of quality	Control Chart	Run chart	Process modeling and simulation	Process capability
Pareto charts	Histogram	Fault tree analysis	Impact/effort matrix	Best practice
CTQ	Scatter diagram	Trend charts	Value stream map	Countermeasure matrix
Gantt chart	Value stream map	Hypothesis tests	Continuous Flow	SMED
Process mapping	Waste analysis	Regression	JIT	TPM
5S	Cycle time	Inferential statistics	Kanban	Cell Manufacturing
Standardisation	Process yield	Spaghetti Analysis	Pull system	Visual controls
		5 why analysis		
		Root cause analysis		
		Constraints		
		Production Leveling		
		Takt time		

Table 17 – Lean Six Sigma problem solving tools (devised by researcher)

From table 17 it can be surmised that the adoption of the 5S tool and Standardisation at the Define phase will ensure that the processes are clean and standardised before investigating the process or product for improvement opportunities. Thereafter, Value Stream Mapping will identify value added and non-value added activities throughout the value stream. This addresses the concern in literature which indicated the Six Sigma does not focus on removing non-value added activities throughout the value stream as reported by De Koning et al. (2008:6) and Arnheiter and Maleyeff (2005:16-17). The investigation of Cycle time and Process yield in the Measure phase will ensure that the efficiency of the process is analysed.

The adoption of Constraints measurement, Production Leveling and Takt time evaluation at the Analyse phase will produce better cause and effect relationships between process and product characteristics. For example, the investigation of long cycle times and waiting times will ensure that maximum operating conditions are generated from each process. This will establish better Flow conditions between processes without interruptions. For the Improve stage, the addition of future state Value Stream Maps, Continuous Flow, JIT, Kanban and Pull systems will establish more efficient process flow with capable processes. This closes the gap in literature which indicated that Lean does not possess the tools to reduce variation while Six Sigma, in contrast, does not attempt to develop a link between quality and speed as does Lean (De Koning et al., 2008:5-7; Su et al., 2006:2; Andersson et al., 2006:293; Bendell, 2006:259). It should be noted that the interaction between the current and future state Value Stream Maps can provide an opportunity to effectively monitor the progress of the Measure, Analyse and Improve phases of the DMAIC cycle. Lastly, the adoption of SMED, TPM, Cell manufacturing, Visual controls and "Poke Yoke" devices at the Control phase will maintain a highly efficient and effective workplace and sustained customer focus.

The wide range of tools in the framework allows employees the opportunity to select the best suited tool for each step of the improvement process. The employees are expected to understand the relationship that exists between certain tools and that a specific tool may be used in more than one step of the DMAIC cycle or even throughout the entire improvement process. The organisation should provide adequate training on basic quality principles and statistical techniques for all employees. The training and development should be integrated with real improvement projects. This will ensure the involvement and participation of employees at all levels of the organisation. As a motivation, the organisation could implement recognition and reward systems for successful projects. The completion of each project is determined by the results achieved to establish if the initial strategical decisions have been satisfied. The effectiveness of the successful projects should be measured in terms of financial and non financial benefits. Unsuccessful projects will result in repeating the cycle.

All of the above elements contribute to the iterative nature of the framework which can be used to achieve continuous improvement in a systematic approach. The integrated and step based implementation methodology of the framework provides leverage for organisations to capture a coherent and holistic approach towards continuous improvement. The Lean Six Sigma framework should be seen as a platform for the initiation of cultural and operational change, leading to total supply chain transformation.

5.6 RESTRICTIONS AND LIMITATIONS

Although this study produced useful and interesting findings, it is understandable that with any research project there are inherent limitations which are likely to surface and could thus present avenues for future research. In this regard, there are six limitations associated with this study as follows:

The first limitation is that there were no organisations in this study that practiced Six Sigma as a standalone technique. The results indicated that Six Sigma is mainly used as an additional continuous improvement tool but has not been embraced as a philosophy. Therefore, the study was unable to positively deduce the effects of standalone Six Sigma implementation. Although the researcher instructed the respondents to answer questions pertaining to Lean and Six Sigma practices as separate entities, there could have been some biased viewpoints in terms of the responses.

The second limitation is that the study was confined to organisations within the DAC which is situated in a single province of South Africa. It does not include automotive component manufacturing organisations from other provinces in South Africa that are geographically dispersed. Therefore, findings are valid for the organisations in question and cannot be generalised across all automotive component manufacturing organisations in South Africa. It would be interesting to investigate how Lean and Six Sigma are sustained in organisations throughout the country.

The third limitation was the design of the questionnaire which did not allow for much explanation of the questions. Although the researcher did provide information on the instructions page of the questionnaire and during the communication channel, there could have been instances where the participants did not understand certain questions. This could perhaps have resulted in the participants misinterpreting or misunderstanding the questions and possibly selecting an answer without any valid reason for their choice. The researcher would never know why a particular response was chosen by the person completing the questionnaire.

The forth limitation was the low response rate of the questionnaire. Although the researcher did initially motivate the reasons for answering the questionnaire and anticipated a 100% response rate from the relatively modest population group, a response rate of 75% was achieved. This was acceptable for the current study; however, owing to this reason, the findings cannot be generalised to the broader community based on this study alone.

The fifth limitation involved the design of the Lean Six Sigma framework. Owing to the scarcity of information in this field, the researcher focused on designing the Lean Six Sigma framework based on critical success factors highlighted in literature together with the results of the empirical study. There could have been other important variables that may be necessary for constructing the framework which the researcher was unable to identify in this study.

The sixth and probably the most significant limitation is that the research extent and scope did not provide an opportunity for the researcher to test if the proposed Lean Six Sigma framework leads to superior performance. Although the researcher would have preferred to test the framework on a real case, the limitation of practical resources and imposed time frame when embarking on such a project prevented this opportunity. Therefore, the proposed Lean Six Sigma framework demonstration by a real case could not be included in this research.

Despite the above limitations, the study contributes to the benchmarking of best practices in the South African automotive sector and to the body of knowledge on Lean Six Sigma.

5.7 CONCLUSION

Although empirical analyses have been performed in the past on various business improvement techniques and their relationship to organisation performance in South Africa, minimum empirical research has been done on the Lean Six Sigma technique. The focus of this research was to better understand the use of Lean and Six Sigma techniques as standalone systems in the KZN automotive sector and to gain an understanding of how well the integrated Lean Six Sigma tool contributes to the business world. The outcome of this project was expected to represent a significant contribution to the theory and practice of Lean Six Sigma in South Africa. In particular, this study developed an operational Lean Six Sigma framework specifically for automotive component manufacturing organisations in KZN.

The start of this study highlighted the question whether independent Lean and Six Sigma, which are said to be very alike but still different, could be connected with or even supplements one another? The research concluded that Lean and Six Sigma have limitations when used as standalone techniques and demonstrated how the integrated Lean Six Sigma technique can produce superior business results when combined by covering the effective areas from both techniques. The results of the Chi square p-values indicated that the weakness of each technique is complemented by the strengths of the other technique. Therefore the null hypothesis can be accepted that a relationship does exist between the integration of Lean and Six Sigma to achieve superior business results. The results from chapter 4 were able to justify the importance of integrating Lean and Six Sigma into a single unified framework from a KZN perspective. The above conclusions are consistent with the authors that have tested the effectiveness of the integrated approach in many occasions and is evident from cited literature and case studies (Delgado et al., 2010:518; Thomas et al., 2009:125-127; Chen and Lyu, 2009:448-451; Su et al., 2006:20).

Although this study enriches the literature by providing in-depth information on the reasons for combining the Lean and Six Sigma techniques, some concerns have been identified through the research process. The study has demonstrated that the sample organisations find it difficult to maintain the transition from theory to practice regarding Lean and Six Sigma implementation. This was demonstrated in the empirical analysis where Lean and Six Sigma organisations only practice certain tools and techniques. It should be noted that even if an organisation claims to have improvement systems in place, there are always opportunities to improve its performance. It is, therefore, recommended that managers in the KZN business environment have structured follow up mechanisms to ensure sustainability of their improvement systems so that it leads to predictable results. The improvement areas identified in this study provide managers in KZN with a checklist (section 5.8.1) for monitoring and measuring the current improvement processes on the shop floor.

It is hoped that the proposed Lean Six Sigma framework in this research will give organisations within the DAC a powerful tool that will assist them in their quest to achieve operational excellence. However, it is important for organisations to realise that Lean Six Sigma is a journey, is timeless and not a destination. The outcome of this analogy is that Lean Six Sigma requires constant evaluation and adjustment to sustain its performance measures in an organisation. In conclusion, it should be emphasised that in an increasingly competitive and globalised environment, the impact of Lean Six Sigma on organisational performance measures is superior to any of the previous quality improvement programs.

5.8 RECOMMENDATIONS

This section highlights the recommendations based on the study pertaining specifically to the research undertaken within organisations in the DAC. Therefore, all perceptions for the following sections need to be contextualised within this regard.

5.8.1 RECOMMENDATIONS BASED ON THE FINDINGS

The research findings indicate that there are performance gaps evident in the sample organisations processes with regard to some of the essential Lean and Six Sigma tools and techniques that are practiced on the shop floor compared to the theoretical requirements. The results from chapter 4 reveal that these tools and techniques are directly linked to the critical success factors of the Lean Six Sigma approach and can thus have an adverse effect on the implementation of the proposed Lean Six Sigma framework if it is not managed effectively. Therefore, the researcher advises that organisations pay closer attention to the following improvement opportunities for each of the seven critical success factors as represented in Table 18. This will represent the checklist to improve the current manufacturing processes within the organisations under study. It is anticipated that once effective corrective actions are taken for the problem areas identified, it will make it easier to implement the proposed Lean Six Sigma framework.

Lean Six Sigma Critical Success Factors	Improvement Area
Organisational Infrstructure	Clearly defining processes and policies within the organisation
	Realignment of the organisations strategy to achieve business goals and results
	Creating a culture of continuous improvement throughout the organisations
Management Leadership/Commitment	Motivating the employees
	Managers spending more time on the production floors
	Defining clear roles and responsibilities within the organisation
	Providing feedback to employees on their performance
Commitment to Quality	Top management demonstrating their commitment to quality
	Providing adequate training on basic quality principles and statistical techniques for all employees
	Using quality data to manage quality
Production Control	Implementation and training of pull production systems
	Maintaining single piece flow between processes
	Implementation and training on Kanban
	Dividing the factory layout into manufacturing cells that encompass product families with similar processing requirements
	Linking the production schedule with the rate of customer demand
	Implementation and training of SMED technique
Process Improvement	Increasing the use of "Poke-Yoke" devices in organisations
	Implementing statistical process control for more equipment and processes
	Implementing measures to assess performance measures and identify possible improvement projects
	Systematic approach to problem solving
	Continuous review of the value stream for improvement opportunities
	Continuous evaluation if processes are adding value
Employee Involvement	Encouraging shop floor employees to participate in problem solving
	Instilling that all employees are responsible for the quality of products
	Allocating responsibilities to shop floor employees
	Motivating employees to come up with suggestions
	Providing recognition or rewards for employees learning new skills
	Training employees to multi-task
	Providing training for employees to perform their functions correctly
	Encouraging teamwork
Customer Focus	Performing customer surveys to listen to the customer concerns
	Using feedback from customers to improve the quality of products

Table 18 – Improvement areas for Lean Six Sigma operations (devised by researcher)

In response to improving the concerns identified in Table 18, the following benefits can be expected:

- Effective process optimisations, strategic thinking throughout the organisation and continuous improvement culture;
- Enhanced responsibilities among the employees and improved interaction between management and employees;

- Quality driven corporate culture;
- Product flow will balance and employees or processes will not wait unnecessarily for material in production; provision of training on “pull systems” and Kanban will ensure complete control of the entire production system;
- Process defects will be reduced and possibly eliminated if immediate corrective action is taken; “Poke Yoke” devices will eliminate biasness of employees and inspection;
- Encouraging employees to be more creative ensures that they are able to make full use of their skills; including more employees in problem solving activities will promote the continuous improvement philosophy; multitasking employees will reduce reliance on designated specialists and indirect departments; developing trust in employees and allocating more responsibilities will create a highly empowered workforce that improves overall performance; increasing open sharing of information and reward systems will motivate employees, and
- Foster establishment of closer ties with the customers

All critical success factors that significantly contribute to the aforementioned improvements are explained in detail in chapter 2. The specific improvements suggest that it is necessary for organisations to review and enhance their existing operations before capitalising on the Lean Six Sigma journey. This is supported by Shah et al. (2008:6696) who suggest that organisations need to carefully assess their current manufacturing processes and capabilities before implementing another technique, which could lead to failure. Techniques such as process mapping, value stream mapping and brainstorming sessions should be consistently maintained within organisations in order to see the entire flow of material movement in production. This is highlighted by Schroeder (2007:409) and Chase et al. (2006:473) as a potential area to continuously improve existing workflows and to ensure that the organisation has a deeper understanding of the current production process. It should be emphasised that value stream mapping is a valuable tool in any organisation to link people and processes as recommended by Comm (2005:71). The critical success factors accompanied by the suggested improvements would ensure that organisations within the DAC achieve huge benefits with the Lean Six Sigma framework both quantitatively and qualitatively.

This work suggests that if an organisation wants improvement to happen on an ongoing basis, it needs to recognise that there are significant interactions between their management system and the improvement technique. When the organisations understand the characteristics of the environment in which they operate it will ensure that they configure appropriate follow up processes to sustain their management systems. This is aligned with Anand et al. (2009:458) who reported in their study the fallacy of simply training employees in new process improvement methods without putting in place mechanisms for managing and maintaining the continuous improvement initiatives. It can be recommended that the critical success factors highlighted in Table 18 are applicable to all organisations and can therefore be integrated into any management system to achieve better performance measures.

5.8.2 RECOMMENDATIONS BASED ON THE STUDY

Since the Lean Six Sigma technique offers a new structure for improvement, it is strongly influenced by management commitment and leadership, culture change, employee involvement and a highly skilled workforce. The structural differences simultaneously promote more control and exploration of the improvement efforts. This is aligned with Arnheiter and Maleyeff (2005:16) who state that the performance of a business is determined by the complex interactions of people, materials, equipment and resources.

The proposed Lean Six Sigma framework in this study reveals that strong management commitment and good leadership skills are required to build a solid organisational foundation to align the Lean Six Sigma philosophy with the organisation’s strategy. This means that management must realise that they are embracing a principle-based system to change the way all work activities are performed. They must provide an environment that is conducive for the employees to succeed by making the time and resources available to adapt to the Lean Six Sigma structure, policies and processes. In seeking to implement the Lean Six Sigma transformation, Pepper and Spedding (2010:144) and Jenicke et al. (2008:461) are in agreement that top managers must clearly communicate the rationale behind the implementation, the expectations from stakeholders and the anticipated results. They believe that management commitment, open communication and involvement of the stakeholders at every stage of the process will ensure success as they are essential for implementation with any attempt at continuous improvement. This research demonstrates that the infrastructure and execution among these constituent elements, such as the employees and the organisations leadership, are critical to sustain the Lean Six Sigma technique.

In terms of cultural changes, the KZN business climate consists of complex and diverse employees which make it difficult to capitalise on the human dimensions that are required for Lean Six Sigma application and effectiveness. This can be overcome with an appropriate organisational infrastructure and a quality-driven culture that are required to change from passive support to proactive participation and learning. It is evident that cultural changes require time and commitment before they are strongly implanted into an organisation. Therefore, it is recommended that management develop an open, honest and transparent quality-driven culture among employees as a means of ensuring the system works effectively. This brings to light that Lean Six Sigma requires a complete transition of the entire organisation.

Another point of recommendation before an organisation decides to implement the Lean Six Sigma technique is that the critical success factors must be understood by all employees in order to make the deployment a success. For a start, management needs to invest in training and education in order to promote learning and continuous improvement to enhance the adopted practices of Lean Six Sigma in the organisation's everyday operations. In addition, the employee's roles and responsibilities must be established and clearly communicated so that the organisation can get greater buy in when all those employees affected are part of the new technique. Therefore, as a method of motivating employees when implementing new systems, it is vital to include them during the entire implementation process as this will motivate them to make the system a success. It can be suggested that although it may not be practical to provide all employees with class room training, the communication strategy used in the organisation through large group meetings, notice boards and newsletters would allow employees to learn the requirements of the Lean Six Sigma technique.

The Lean Six Sigma technique should not be considered as a tool to solve complex problems in an organisation. Lee-Mortimer (2006:14) suggests that it is vital for management to understand the business before deciding on which improvement initiative is most suitable for their application. Therefore, it is important to note that the Lean Six Sigma framework designed for automotive component manufacturing organisations in KZN do not entail simply practicing the tools but rather adopting a philosophy which the employees bring into reality. Perhaps management in general should pay much closer attention to using structured performance evaluators and follow up procedures to continually monitor the Lean Six Sigma process and thereby ensure sustainability of the system.

Aside from designing a KZN Lean Six Sigma framework, this research has demonstrated how commitment and collaboration between the management and employees affect the outcome of implementing continuous improvement programs. It is recommended that managers spend more time on the production floor as a means of convincing the employees that all operations are important. This type of interaction and leadership commitment will ensure that the expected culture change required for improvement programs is embraced together throughout the organisation. It is also advised that organisational motivation be increased by explaining the reasons for change in the current competitive business environment.

5.8.3 RECOMMENDATIONS FOR THE AUTOMOTIVE INDUSTRY

As global competition in the automotive sector increases, the demand for quality products increase and therefore organisations must embrace improvement techniques such as Lean Six Sigma to compete more effectively and improve their performance. This study benchmarks two of the best practices in the world and addresses the problem of choosing the most suitable improvement techniques for tailoring them to the given environment. Since the automotive industry plays a key role in the South African economy, the problems identified in organisations that practice Lean and Six Sigma as standalone techniques have a significant impact on their operations and competitiveness. This directly impacts the country's economy.

The recommendations made to the DAC and the South African automotive industry as a whole is that Lean Six Sigma repackages the stronger focus areas of Lean and Six Sigma to create its own unique approach on how to improve an organisation's performance. These recommendations can either be standardised or further developed into future research studies. It is anticipated that organisations which implement the proposed Lean Six Sigma framework would significantly contribute to the growth of the South African economy as a result of increased productivity, improved international competition and job creation.

The Lean Six Sigma technique provides a useful framework for systematically developing and managing innovations and improvements that can be shared among suppliers and customers within the automotive industry and will ensure that common practices can be learnt and implemented within this sector. Such actions will assist the South African automotive industry to compete favourably against its international counterparts. Hence, the Lean Six Sigma technique should be infused with the organisation's strategy and not be treated as another standalone system. The proposed Lean Six Sigma framework affords the KZN automotive sector a unique opportunity to create its own brand of quality that complements its management style and industry demands.

5.8.4 RECOMMENDATIONS FOR FUTURE RESEARCH

Upon reviewing the limitations of this study the researcher identified many areas which need to be investigated and enhanced. These areas provide a number of inspirations for potential future research activities and are thus recommended as follows:

- Extending this research into the entire geographical diversity of the South African automotive sector to learn more about other organisations that claim to practice Six Sigma independently and rank their existing state. This would present more opportunities for discovering the real life situations for optimal performance of Six Sigma and the actual expectations of the respondents for the success of Six Sigma as well as the reasons that they are not met.
- Performing similar empirical studies of this nature in different manufacturing sectors and service settings in South Africa. This is supported by the literature (Laureani and Antony, 2010:689; Nauhria et al., 2009:39) which indicates that Lean Six Sigma has been embraced in a wide range of business sectors that includes both manufacturing and services. If a similar study is performed in a different sector, it can be used to determine whether other industries in South Africa face similar challenges as those in the automotive sector. The suggestion for future work will also test and establish whether the findings are similar to other industries with those of this study.
- Conducting a more detailed study, through a larger population group with various available resources and involvement of more organisations in the immediate future will provide greater validity of the findings from this research. This would ensure that more rigorous conclusions can be drawn from the study.
- Testing the validity of the proposed Lean Six Sigma framework in a real case application to ensure that the critical outcomes are adequately ingrained to achieve perceived organisational performance. Future work should therefore primarily be focused on understanding the relationship between actual performance measures and the expectations of the integrated Lean Six Sigma framework. This would enable a deeper understanding of Lean Six Sigma implementation in the KZN automotive sector and

empirically validate the effectiveness of the framework in the real world to identify improvement opportunities.

- Investigating a universal Lean Six Sigma framework for manufacturing organisations such as the International Organisation for Standardisation quality management systems. The proposed Lean Six Sigma framework in this study can be critiqued and compared to other frameworks throughout the world to assist in designing a universal framework. The global study would establish best in class practice of a universal Lean Six Sigma framework.
- Developing a list of performance evaluators and follow up procedures to monitor the progress of the Lean Six Sigma technique. This would ensure that organisations are continuously obtaining positive results through the Lean Six Sigma technique. A pilot study can target specific industries to provide a descriptive account of the issues involved in Lean Six Sigma projects and the impact on organisation performance.

The above recommendations form part of the evolutionary process of the topic as the core principles of Lean Six Sigma will continue to grow in the future.

5.9 FINAL CONCLUDING REMARKS

This research is among the first attempt to investigate the rationale of the integrated Lean Six Sigma technique in the South African automotive sector. The research identified two major findings. Firstly, this study has demonstrated how organisations utilise Lean and Six Sigma techniques but find it difficult to complete the transition from theory to practice. This was proven from the empirically validated evidence generated by the study as to what prevails on the shop floor compared to what is documented and perceived to be working by management. Secondly, this study presented a Lean Six Sigma framework based on key factors that emerged from literature and the analysis of qualitative and quantitative research findings. The Lean Six Sigma framework is expected to assist organisations achieve world class level as it revolves around a balanced approach to business improvement with methods for basic problem solving and approaches to continuous process improvement. It forms a powerful business strategy that can assist the automotive component manufacturers in KZN to become the very best in confronting global challenges.

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PILOT STUDY QUESTIONNAIRE **ANNEXURE A**

SURVEY QUESTIONNAIRE

A LEAN SIX SIGMA FRAMEWORK TO ENHANCE THE COMPETITIVENESS IN SELECTED AUTOMOTIVE COMPONENT MANUFACTURING ORGANISATIONS

Dear Respondent

To compete with the rest of the world where productivity, quality and operational costs reduction are crucial for economic success, South African manufacturing organisations need to be flexible to improve their business operations and enhance innovations in processes, products and services in a very proactive manner. Business leaders in South Africa adopt various improvement techniques through consultants, government fundings, industry clusters or support from global sister companies to improve performance. The latest being either Lean or Six Sigma. These improvement techniques are adopted mainly as standalone and used in isolation. There appears to be no innovation to suggest that South African manufacturing organisations are considering the integrated Lean Six Sigma methodology as an overall business improvement framework.

In relation to the above, a transformation is needed for South African manufacturing organisations to consider a methodology that uses the best of both techniques to achieve better business results. Therefore the aim of this study, conducted under the guidance of the Faculty of Management Sciences at Durban University of Technology and with the support of the Durban Automotive Cluster is to develop a theoretical framework that integrates Lean and Six Sigma into a conceptual business improvement tool for South African manufacturing organisations in the automotive sector. I would like to take this opportunity to thank you in advance for your willingness and time to participate in this survey. It is anticipated that the results will provide a customised implementation framework for South African manufacturing organisations in the automotive sector to be more competitive and contribute to the country's economy.

Raveen Rathilall	Dr. S. Singh	Mr. S. Ellis
Researcher	Research Promoter	Project Manager
Student	Durban University of Technology	Durban Automotive Cluster

Guidelines and Instructions for Completing the Questionnaire

Note to the respondent

- I need your help to understand how effective the applications of improvement techniques are currently managed in your organisation.
- What you say in this questionnaire will remain private and confidential. No one will be able to trace your opinions back to you as a person.
- Please note that there is no correct or incorrect answer and try to answer all questions even if the alternatives do not necessarily suit your opinion.

How to complete the questionnaire

1. Please answer the questions as truthfully as you can. The questions are divided into five sections and are as follows:
   Section A – General information regarding your organisation
   Section B – Questions pertaining to organisations that operate with Lean
   Section C – Questions pertaining to organisations that operate with Six Sigma
   Section D – Questions pertaining to the infrastructures currently in place in your organisation and requires making a selection from "do not agree at all" with a value of (1) to "agree fully" with a value of (5).
   Section E – Requires selecting from the list of quality and improvement tools that is currently used in your organisation

Selection criteria for answering the questionnaire:

- **If your organisation practices Lean, please answer section A, B, D and E**
- **If your organisation practices Six Sigma, please answer section A, C, D and E**
- **If your organisation does not practice Lean or Six Sigma, please answer section A, D and E only**
- **If your organisation practices both Lean and Six Sigma, please answer all sections**

2. You can mark a question that requires your response with a cross.
3. Please answer the questionnaire with a pen if you do not intend to use a computer.
4. Please answer all questions according to the prescribed selection criteria and it will take you no longer than 25 minutes.
5. The completed questionnaire can be forwarded to myself by no later than 31 March 2013 through the following means:
   e-mail: raveen.rathilall@za.behrgroup.com
   fax: (031) 705 9886 / 086 601 5981

Please indicate your contact details below, should you require a summary of the research findings:

____

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____

____

SECTION A – GENERAL INFORMATION

Which of the following best describes your industry in the automotive sector? Please select one	
Trim	
Harnesses	
Electronics	
Foundries / Forges	
JIT Assembly	
Metal Forming / Pressing	
Metal Fabrication	
Components	
Glass	
Heat Transfer	
Precision Machining	
Plastic Moulding	
Other (please specify):	

Which of the following best describes your existing position in the organisation? Please select one	
Executive / Board Member	
Senior Manager	
Manager	
Foreman / Superintendent	
Engineer	
Technician	
Lean Specialist	
Six Sigma Specialist	
Other (please specify):	

Which of the following best describes your department in the organisation? Please select one	
Operations / Production	
Engineering / Technical	
Maintenance / HSE	
Quality / Continuous Improvement	
Logistics / Procurement	
Finance / Administration	
Marketing / Sales	
Human Resource / Training	
Information Technology	
Industrial / Process Engineering	
CEO / Shareholder	
Other (please specify):	

How long have you been employed within the organisation? Please select one	
Under 1 year	
1 – 3 years	
3 – 5 years	
5 – 10 years	
10 – 15 years	
15 – 20 years	
Greater than 20 years	

The total number of employees in your organisation? Please select one	
Under 50	
50 - 100	
100 - 250	
250 - 500	
500 - 750	
750 - 1000	
Greater than 1000	

SECTION B - LEAN ORGANISATIONS

1.1 For how long is your organisation practicing Lean?

Less than 1 year		1 to 2 years		2 to 5 years		5 to 10 years		Greater than 10 years	

1.2 What was the reason for Lean deployment in your organisation? Please select one.

Increase in revenue		Enhance improvements	
Reduce costs		Improve quality and productivity	
Become more competitive		Prescribed by head office	
Other (please specify):			

1.3 Did the management/leadership style change to accommodate Lean?

Yes		No	

Explain: ____

____

1.4 Was Lean accepted by the diversity of employees in the organisation?

Yes		No	

Explain: ____

____

1.5 On a scale of 1 – 5 how would you rate the level of management/leadership commitment within the organisation to drive, live and demonstrate Lean behavior ______

1 – Very little Commitment; 2 - Commitment; 3 – Average Commitment; 4 – High level of Commitment; 5 – Very high level of Commitment

1.6 On a scale of 1 – 5 how would you rate the level of employee involvement to achieve the Lean goals. ______

1 – Very little involvement; 2 – Little involvement; 3 – Average participation; 4 – High level of involvement; 5 – Very high level of involvement

1.7 On a scale of 1 – 5 how would you rate the level of the employees understanding towards Lean and where the business is heading ______

1 – Very little understanding; 2 – Little understanding; 3 – Average understanding; 4 – High level of understanding; 5 – Very high level of understanding

1.8 On a scale of 1 – 5 how would you rate the methods that the organisation has in place to continuously develop and sustain the Lean culture ______

1 – Very insufficient; 2 - Insufficient; 3 - Average; 4 – Sufficient; 5 – Very sufficient

1.9 Please select from the list of improvements presented in the table below all those that occurred within the organisation since the adoption of the Lean technique.

Elimination of waste		Reduction in cycle times	
Reduction in lead time		Reduction in manufacturing costs	
Improved staff morale		Improvement in quality	
Improvement in space utilisation		Improvement to the flow of materials	
Reduction in WIP and finished goods inventory		Improvement in working capital and employee productivity	
System interaction considered for all processes to be improved together		Improved speed and responsiveness to customer needs	
Established visual management techniques		Created a continuous improvement culture	
Questions if all processes are adding value		Continuously challenge the way we work	
Other (please specify):			

1.10 What else would you like see other than the above improvements?

____

____

1.11 How would you rate the success level of Lean adoption within the organisation.

Total failure		Some success	
Many areas were successful		Total success	
Other (please specify):			

1.12 What deficiencies have been identified with the Lean technique since its inception?

____

____

1.13 What activities are planned to improve Lean knowledge and practice in the organisation?

____

____

1.14 Aside from the improvements that Lean brings to the workplace, does the organisation focus on the following improvement areas? (Indicate "Y" for Yes or "N" for No next to each improvement area highlighted in the table below)

Statistical Process Control		Uniform process output	
Process capability and stability		Reducing process variability	
Systematic problem solving approach		Emphasises on creativity and innovation	
Examining variations in measurement systems during decision making		Linking advanced statistical and analytical tools to diagnose process improvement	
Investigating more robust and effective processes		Producing higher customer satisfaction levels	
Considering the impact improvements have on the organisations profit margins		Designated improvement specialists to work with improvement projects	
Other (please specify):			

1.15 In relation to the previous question, do you think the Lean technique is achieving perceived business performance in the organisation?

Yes		No	

Explain: ____

____

1.16 What is your overall perception of Lean?

____

____

SECTION C – SIX SIGMA ORGANISATIONS

1.1 For how long is your organisation practicing Six Sigma?

Less than 1 year		1 to 2 years		2 to 5 years		5 to 10 years		Greater than 10 years	

1.2 What was the reason for Six Sigma deployment in your organisation? Please select one.

Increase in revenue		Enhance improvements	
Reduce costs		Improve quality and productivity	
Become more competitive		Prescribed by head office	
Other (please specify):			

1.3 Did the management/leadership style change to accommodate Six Sigma?

Yes		No	

Explain: ____

____

1.4 Was Six Sigma accepted by the diversity of employees in the organisation?

Yes		No	

Explain: ____

____

1.5 On a scale of 1 – 5 how would you rate the level of management/leadership commitment within the organisation to drive, live and demonstrate Six Sigma behavior ______

1 – Very little Commitment; 2 - Commitment; 3 – Average Commitment; 4 – High level of Commitment; 5 – Very high level of Commitment

1.6 On a scale of 1 – 5 how would you rate the level of employee involvement to achieve the Six Sigma goals. ______

1 – Very little involvement; 2 – Little involvement; 3 – Average participation; 4 – High level of involvement; 5 – Very high level of involvement

1.7 On a scale of 1 – 5 how would you rate the level of the employees understanding towards Six Sigma and where the business is heading ______

1 – Very little understanding; 2 – Little understanding; 3 – Average understanding; 4 – High level of understanding; 5 – Very high level of understanding

1.8 On a scale of 1 – 5 how would you rate the methods that the organisation has in place to continuously develop and sustain the Six Sigma culture ______

1 – Very insufficient; 2 - Insufficient; 3 - Average; 4 – Sufficient; 5 – Very sufficient

1.9 Please select from the list of improvements presented in the table below all those that occurred within the organisation since the adoption of the Six Sigma technique.

Statistical Process Control		Uniform process output	
Process capability and stability		Reducing process variability	
Systematic problem solving approach		Emphasises on creativity and innovation	
Examining variations in measurement systems during decision making		Linking advanced statistical and analytical tools to diagnose process improvement	
Investigating more robust and effective processes		Producing higher customer satisfaction levels	
Considering the impact improvements have on the organisations profit margins		Designated improvement specialists to work with improvement projects	
Reduction in manufacturing costs		Improvement in quality and productivity	
Other (please specify):			

1.10 What else would you like see other than the above improvements?

____

____

1.11 How would you rate the success level of the Six Sigma adoption within the organisation.

Total failure		Some success	
Many areas were successful		Total success	
Other (please specify):			

1.12 What deficiencies have been identified in the Six Sigma technique since its inception?

____

____

1.13 What activities are planned to improve Six Sigma knowledge and practice in the organisation?

____

____

1.14 Aside from improvements that Six Sigma brings to the workplace, does the organisation focus on the following improvement areas? (Indicate "Y" for Yes or "N" for No next to each improvement area highlighted in the table below)

Elimination of waste		Reduction in cycle times	
Reduction in lead time		Questions if all processes are adding value	
Improved staff morale		Continuously challenge the way we work	
Improvement in space utilisation		Improvement to the flow of materials	
Reduction in WIP and finished goods inventory		Improvement in working capital and employee productivity	
Consideration of system interaction for all processes to be improved together		Improving speed and responsiveness to customer needs	
Establishing visual management techniques		Continuous improvement culture	
Other (please specify):			

1.15 In relation to the previous question, do you think the Six Sigma technique is achieving perceived business performance in the organisation?

Yes		No	

Explain: ____

____

1.16 What is your overall perception of Six Sigma?

____

____

SECTION D – LEAN SIX SIGMA SUCCESS FACTORS

1	**Organisational Infrastructure**	**Strongly Disagree**	**Disagree**	**Neutral / Unsure**	**Agree**	**Strongly Agree**
1.1	All processes and policies within the organisation are well defined and maintained					
1.2	The organisation's strategies are focused on goals and results to achieve competitive advantage					
1.3	The organisation commits to modifying systems and structures to support business assurance					
1.4	The organisation respects and supports the diversity of different cultures					
1.5	A culture of continuous improvement is visible on the shop floor and throughout the organisation					

2	**Management Commitment / Leadership**	**Strongly Disagree**	**Disagree**	**Neutral / Unsure**	**Agree**	**Strongly Agree**
2.1	The management team knows how to build motivation in the organisation					
2.2	Management has arrangements to support skills, experience and competence retention					
2.3	Managers go to where the action takes place (Gemba)					
2.4	Management defines the appropriate roles and responsibilities within the organisation					
2.5	Management provides continuous feedback to employees on their performance					

3	**Commitment to Quality**	**Strongly Disagree**	**Disagree**	**Neutral / Unsure**	**Agree**	**Strongly Agree**
3.1	Top management (i.e. top executives and major department heads) assumes responsibility for quality performance					
3.2	Top management provides personal leadership for quality products and quality improvements					
3.3	All employees are adequately trained on basic quality principles and statistical techniques					
3.4	Quality data (error rates, defect rates, scrap, defects, cost of quality, etc) are available throughout the plant					
3.5	Quality data are used to manage quality					
3.6	The organisation faces up to problems immediately as they arise to make effective decisions					

4	**Production Control**	**Strongly Disagree**	**Disagree**	**Neutral / Unsure**	**Agree**	**Strongly Agree**
4.1	We use a pull production system in our manufacturing process					
4.2	Single piece flow of material is maintained between processes					
4.3	We use Kanban systems to signal for material requirements in each process					
4.4	The factory layout is divided into manufacturing cells that encompass product families with similar processing requirements					
4.5	The production schedule is directly linked with the rate of customer demand					
4.6	We use the SMED technique to provide rapid change-over of tooling and fixtures					
4.7	The seven forms of production waste (overproduction, waiting, transportation, processing, inventory, motion, defects) are identified and highlighted in our processes					
4.8	We practice the 5S tool to ensure that the organisations shop floors are well organised, clean and safe					
4.9	We have standard operating procedures for all processes					
4.10	Production is stopped immediately for every abnormality					

5	**Process Improvement**	**Strongly Disagree**	**Disagree**	**Neutral / Unsure**	**Agree**	**Strongly Agree**
5.1	"Poke-Yoke" devices are used in our organisation to minimize the chances of errors					
5.2	Clear process instructions are given to employees					
5.3	All equipment and processes on the shop floor are under statistical process control					
5.4	Measures are in place to assess process performance and identify possible improvements projects					
5.5	All improvement projects are structured and undertaken systematically					
5.6	There is an appropriate infrastructure of improvement specialists in the organisation					
5.6	All significant process improvement decisions are based on facts that are gathered from statistical data					
5.8	The value stream is continuously evaluated and monitored for improvement opportunities					
5.9	All processes are continuously questioned if it is adding value					

6	Employee Involvement	Strongly Disagree	Disagree	Neutral / Unsure	Agree	Strongly Agree
6.1	Shop floor employees participate in problem solving					
6.2	Shop floor employees perform their own quality checks					
6.3	Shop floor employees fix minor quality problems as they occur					
6.4	Shop floor employees perform general maintenance of equipment					
6.5	Employees are recognised for going the extra mile and making superior quality improvement					
6.6	Employees are motivated to come up with improvement suggestions					
6.7	Employees are rewarded for learning new skills					
6.8	Sufficient cross functional training is provided to multi-skill employees					
6.9	All employees are adequately trained to perform their functions					
6.10	All employees are encouraged to assist across the different functions and work as a team					
6.11	All employees are encouraged to challenge the way they work					
6.12	Employees are encouraged to learn from mistakes so that we don't repeat them					

7	Customer Focus	Strongly Disagree	Disagree	Neutral / Unsure	Agree	Strongly Agree
7.1	We frequently are in close contact with our customers					
7.2	Customer surveys are used to elicit customer needs and "Voice Of Customer" information					
7.3	Our employees know our customers and competitors					
7.4	Our customers are directly involved in current and future product offerings					
7.5	We use customer requirements as the basis for quality improvement					
7.6	Our customers frequently share current and future demand information with our organisation					
7.7	We continuously build customer confidence and create a clear understanding of our market					

SECTION E – IMPROVEMENT TOOLS AND TECHNIQUES

Please select from list of quality improvement tools and techniques presented in the table below all of those that are commonly used in your organisation:

Mark appropriate selections with "X"			
Affinity Diagram		Control Chart	
Pareto Chart		Force Field Analysis	
Process mapping		Run Charts	
Value Added Flowchart		Scatter Plot	
Project Priority Calculator		Matrix Analysis	
Failure Mode and Effect Analysis		Normal Probability Plot	
Spaghetti Diagrams		Root Cause Analysis	
Measurement System Analysis / Gage R&R		Fault Tree Analysis	
Trend Charts		Gantt Chart	
Capability Indices / Process Capability		Critical to Quality Analysis (CTQ)	
Cause and Effect Diagram (Fishbone)		Standardisation	
Histogram		Waste Analysis	
5-Why Analysis		Customer Surveys	
Regression Analysis		Kano Model	
Design of Experiments		House of Quality	
Hypothesis Testing		Check Sheet	
Kano Analysis		Control Plan	
Analysis of Variance		CHECK Process	
Brainstorming		5S	
Systems Diagrams		SIPOC	
Error Proofing (Poke-Yoke)		Quality Function Deployment	
Corrective Action Matrix		Just In Time	

END **THANK YOU.**

MAIN STUDY QUESTIONNAIRE ANNEXURE B

SURVEY QUESTIONNAIRE

A LEAN SIX SIGMA FRAMEWORK TO ENHANCE THE COMPETITIVENESS IN SELECTED AUTOMOTIVE COMPONENT MANUFACTURING ORGANISATIONS

Dear Respondent

To compete with the rest of the world where productivity, quality and operational costs reduction are crucial for economic success, South African manufacturing organisations need to be flexible to improve their business operations and enhance innovations in processes, products and services in a very proactive manner. Business leaders in South Africa adopt various improvement techniques through consultants, government fundings, industry clusters or support from global sister companies to improve performance. The latest being either Lean or Six Sigma. These improvement techniques are adopted mainly as standalone and used in isolation. There appears to be no innovation to suggest that South African manufacturing organisations are considering the integrated Lean Six Sigma methodology as an overall business improvement framework.

In relation to the above, a transformation is needed for South African manufacturing organisations to consider a methodology that uses the best of both techniques to achieve better business results. Therefore the aim of this study, conducted under the guidance of the Faculty of Management Sciences at Durban University of Technology and with the support of the Durban Automotive Cluster is to develop a theoretical framework that integrates Lean and Six Sigma into a conceptual business improvement tool for South African manufacturing organisations in the automotive sector. I would like to take this opportunity to thank you in advance for your willingness and time to participate in this survey. It is anticipated that the results will provide a customised implementation framework for South African manufacturing organisations in the automotive sector to be more competitive and contribute to the country's economy.

Raveen Rathilall	Dr. S. Singh	Mr. S. Ellis
Researcher	Research Promoter	Project Manager
Student	Durban University of Technology	Durban Automotive Cluster

Guidelines and Instructions for Completing the Questionnaire

Note to the respondent

- I need your help to understand how effective the applications of improvement techniques are currently managed in your organisation.
- What you say in this questionnaire will remain private and confidential. No one will be able to trace your opinions back to you as a person.
- Please note that there is no correct or incorrect answer and try to answer all questions even if the alternatives do not necessarily suit your opinion.

How to complete the questionnaire

6. Please answer the questions as truthfully as you can. The questions are divided into five sections and are as follows:
   Section A – General information regarding your organisation
   Section B – Questions pertaining to organisations that operate with Lean
   Section C – Questions pertaining to organisations that operate with Six Sigma
   Section D – Questions pertaining to the infrastructures currently in place in your organisation and requires making a selection from "do not agree at all" with a value of (1) to "agree fully" with a value of (5).
   Section E – Requires selecting from the list of quality and improvement tools that is currently used in your organisation

Selection criteria for answering the questionnaire:

- **If your organisation practices Lean, please answer section A, B, D and E**
- **If your organisation practices Six Sigma, please answer section A, C, D and E**
- **If your organisation does not practice Lean or Six Sigma, please answer section A, D and E only**
- **If your organisation practices both Lean and Six Sigma, please answer all sections (Nb. Please answer the sections on Lean and Six Sigma as separate entities)**

7. You can mark a question that requires your response with a cross.
8. Please answer the questionnaire with a pen if you do not intend to use a computer.
9. Please answer all questions according to the prescribed selection criteria and it will take you no longer than 45 minutes.
10. The completed questionnaire can be forwarded to myself by no later than 31 March 2013 through the following means:
    e-mail: raveen.rathilall@za.behrgroup.com
    fax: (031) 705 9886 / 086 601 5981

Please indicate your contact details below, should you require a summary of the research findings:

____

____

____

____

SECTION A – GENERAL INFORMATION

Which of the following best describes your industry in the automotive sector? Please select one	
Trim	
Harnesses	
Electronics	
Foundries / Forges	
JIT Assembly	
Metal Forming / Pressing	
Metal Fabrication	
Components	
Glass	
Heat Transfer	
Precision Machining	
Plastic Moulding	
Other (please specify):	

Which of the following best describes your existing position in the organisation? Please select one	
Executive / Board Member	
Senior Manager	
Manager	
Foreman / Superintendent	
Engineer	
Technician	
Lean Specialist	
Six Sigma Specialist	
Other (please specify):	

How long have you been employed within the organisation? Please select one	
Under 1 year	
1 – 3 years	
3 – 5 years	
5 – 10 years	
10 – 15 years	
15 – 20 years	
Greater than 20 years	

The total number of employees in your organisation? Please select one	
Under 50	
50 - 100	
100 - 250	
250 - 500	
500 - 750	
750 - 1000	
Greater than 1000	

SECTION B - LEAN ORGANISATIONS

1.1 For how long is your organisation practicing Lean?

Less than 1 year		1 to 2 years		2 to 5 years		5 to 10 years		Greater than 10 years	

1.2 What was the reason for Lean deployment in your organisation? Please select one.

Increase in revenue		Enhance improvements	
Reduce costs		Improve quality and productivity	
Become more competitive		Prescribed by head office	
Other (please specify):			

1.3 Did the management/leadership style change to accommodate Lean?

Yes		No	

Explain: ____

____

1.4 Was Lean accepted by the diversity of employees in the organisation?

Yes		No	

Explain: ____

____

1.5 On a scale of 1 – 5 how would you rate the level of management/leadership commitment within the organisation to drive, live and demonstrate Lean behavior ______

1 – Very little Commitment; 2 - Commitment; 3 – Average Commitment; 4 – High level of Commitment; 5 – Very high level of Commitment

1.6 On a scale of 1 – 5 how would you rate the level of employee involvement to achieve the Lean goals. ______

1 – Very little involvement; 2 – Little involvement; 3 – Average participation; 4 – High level of involvement; 5 – Very high level of involvement

1.7 On a scale of 1 – 5 how would you rate the level of the employees understanding towards Lean and where the business is heading ______

1 – Very little understanding; 2 – Little understanding; 3 – Average understanding; 4 – High level of understanding; 5 – Very high level of understanding

1.8 On a scale of 1 – 5 how would you rate the methods that the organisation has in place to continuously develop and sustain the Lean culture ______

1 – Very insufficient; 2 - Insufficient; 3 - Average; 4 – Sufficient; 5 – Very sufficient

1.9 How would you rate the success level of Lean adoption within the organisation.

Total failure		Some success	
Many areas were successful		Total success	
Other (please specify):			

1.10 What activities are planned to improve Lean knowledge and practice in the organisation?

____

____

1.11 Please select from the list of improvements presented in the table below all those that occurred within the organisation since the adoption of the Lean technique.

Elimination of waste		Reduction in cycle times	
Reduction in lead time		Reduction in manufacturing costs	
Improved staff morale		Improvement in quality	
Improvement in space utilisation		Improvement to the flow of materials	
Reduction in WIP and finished goods inventory		Improvement in working capital and employee productivity	
System interaction considered for all processes to be improved together		Improved speed and responsiveness to customer needs	
Established visual management techniques		Created a continuous improvement culture	
Questions if all processes are adding value		Continuously challenge the way we work	
Other (please specify):			

1.12 What deficiencies have been identified with the Lean technique since its inception?

____

____

1.13 Aside from the improvements that Lean brings to the workplace, does the organisation focus on the following improvement areas? (Indicate "Y" for Yes or "N" for No next to each improvement area highlighted in the table below)

Statistical Process Control		Uniform process output	
Process capability and stability		Reducing process variability	
Systematic problem solving approach		Emphasises on creativity and innovation	
Examining variations in measurement systems during decision making		Linking advanced statistical and analytical tools to diagnose process improvement	
Investigating more robust and effective processes		Producing higher customer satisfaction levels	
Considering the impact improvements have on the organisations profit margins		Designated improvement specialists to work with improvement projects	
Other (please specify):			

1.14 In relation to the previous question, do you think the Lean technique is achieving perceived business performance in the organisation?

Yes		No	

Explain: ____

____

1.15 What is your overall perception of Lean?

____

____

SECTION C – SIX SIGMA ORGANISATIONS

1.1 For how long is your organisation practicing Six Sigma?

Less than 1 year		1 to 2 years		2 to 5 years		5 to 10 years		Greater than 10 years	

1.2 What was the reason for Six Sigma deployment in your organisation? Please select one.

Increase in revenue		Enhance improvements	
Reduce costs		Improve quality and productivity	
Become more competitive		Prescribed by head office	
Other (please specify):			

1.3 Did the management/leadership style change to accommodate Six Sigma?

Yes		No	

Explain: ____

____

1.4 Was Six Sigma accepted by the diversity of employees in the organisation?

Yes		No	

Explain: ____

____

1.5 On a scale of 1 – 5 how would you rate the level of management/leadership commitment within the organisation to drive, live and demonstrate Six Sigma behavior ______

1 – Very little Commitment; 2 - Commitment; 3 – Average Commitment; 4 – High level of Commitment; 5 – Very high level of Commitment

1.6 On a scale of 1 – 5 how would you rate the level of employee involvement to achieve the Six Sigma goals. ______

1 – Very little involvement; 2 – Little involvement; 3 – Average participation; 4 – High level of involvement; 5 – Very high level of involvement

1.7 On a scale of 1 – 5 how would you rate the level of the employees understanding towards Six Sigma and where the business is heading ______

1 – Very little understanding; 2 – Little understanding; 3 – Average understanding; 4 – High level of understanding; 5 – Very high level of understanding

1.8 On a scale of 1 – 5 how would you rate the methods that the organisation has in place to continuously develop and sustain the Six Sigma culture ______

1 – Very insufficient; 2 - Insufficient; 3 - Average; 4 – Sufficient; 5 – Very sufficient

1.9 How would you rate the success level of the Six Sigma adoption within the organisation.

Total failure		Some success	
Many areas were successful		Total success	
Other (please specify):			

1.10 What activities are planned to improve Six Sigma knowledge and practice in the organisation?

____

____

1.11 Please select from the list of improvements presented in the table below all those that occurred within the organisation since the adoption of the Six Sigma technique.

Statistical Process Control		Uniform process output	
Process capability and stability		Reducing process variability	
Systematic problem solving approach		Emphasises on creativity and innovation	
Examining variations in measurement systems during decision making		Linking advanced statistical and analytical tools to diagnose process improvement	
Investigating more robust and effective processes		Producing higher customer satisfaction levels	
Considering the impact improvements have on the organisations profit margins		Designated improvement specialists to work with improvement projects	
Reduction in manufacturing costs		Improvement in quality and productivity	
Other (please specify):			

1.12 What deficiencies have been identified in the Six Sigma technique since its inception?

____

____

1.13 Aside from improvements that Six Sigma brings to the workplace, does the organisation focus on the following improvement areas? (Indicate "Y" for Yes or "N" for No next to each improvement area highlighted in the table below)

Elimination of waste		Reduction in cycle times	
Reduction in lead time		Questions if all processes are adding value	
Improved staff morale		Continuously challenge the way we work	
Improvement in space utilisation		Improvement to the flow of materials	
Reduction in WIP and finished goods inventory		Improvement in working capital and employee productivity	
Consideration of system interaction for all processes to be improved together		Improving speed and responsiveness to customer needs	
Establishing visual management techniques		Continuous improvement culture	
Other (please specify):			

1.14 In relation to the previous question, do you think the Six Sigma technique is achieving perceived business performance in the organisation?

Yes		No	

Explain: ____

____

1.15 What is your overall perception of Six Sigma?

____

____

SECTION D – LEAN SIX SIGMA SUCCESS FACTORS

1	Organisational Infrastructure	Strongly Disagree	Disagree	Neutral / Unsure	Agree	Strongly Agree
1.1	All processes and policies within the organisation are well defined and maintained					
1.2	The organisation's strategies are focused on goals and results to achieve competitive advantage					
1.3	The organisation commits to modifying systems and structures to support business assurance					
1.4	The organisation respects and supports the diversity of different cultures					
1.5	A culture of continuous improvement is visible on the shop floor and throughout the organisation					

2	Management Commitment / Leadership	Strongly Disagree	Disagree	Neutral / Unsure	Agree	Strongly Agree
2.1	The management team knows how to build motivation in the organisation					
2.2	Management has arrangements to support skills, experience and competence retention					
2.3	Managers go to where the action takes place (Gemba)					
2.4	Management defines the appropriate roles and responsibilities within the organisation					
2.5	Management provides continuous feedback to employees on their performance					

3	Commitment to Quality	Strongly Disagree	Disagree	Neutral / Unsure	Agree	Strongly Agree
3.1	Top management (i.e. top executives and major department heads) assume responsibility for quality performance					
3.2	Top management provides personal leadership for quality products and quality improvements					
3.3	All employees are adequately trained on basic quality principles and statistical techniques					
3.4	Quality data (error rates, defect rates, scrap, defects, cost of quality) are available throughout the plant					
3.5	Quality data are used as tools to manage quality					
3.6	The organisation faces up to problems immediately as they arise and makes effective decisions					

4	**Production Control**	**Strongly Disagree**	**Disagree**	**Neutral / Unsure**	**Agree**	**Strongly Agree**
4.1	We use a pull production system in our manufacturing process					
4.2	Single piece flow of material is maintained between processes					
4.3	We use Kanban systems to signal for material requirements in each process					
4.4	The factory layout is divided into manufacturing cells that encompass product families with similar processing requirements					
4.5	The production schedule is directly linked with the rate of customer demand					
4.6	We use the SMED technique to provide rapid change-over of tooling and fixtures					
4.7	The seven forms of production waste (overproduction, waiting, transportation, processing, inventory, motion, defects) are identified and highlighted in our processes					
4.8	We practice the 5S tool to ensure that the organisations shop floors are well organised, clean and safe					
4.9	We have standard operating procedures for all processes					
4.10	Production is stopped immediately for every abnormality					

5	**Process Improvement**	**Strongly Disagree**	**Disagree**	**Neutral / Unsure**	**Agree**	**Strongly Agree**
5.1	"Poke-Yoke" devices are used in our organisation to minimize the chances of errors					
5.2	Clear process instructions are given to employees					
5.3	All equipment and processes on the shop floor are under statistical process control					
5.4	Measures are in place to assess process performance and identify possible improvements projects					
5.5	All improvement projects are structured and undertaken systematically					
5.6	There is an appropriate infrastructure of improvement specialists in the organisation					
5.6	All significant process improvement decisions are based on facts that are gathered from statistical data					
5.8	The value stream is continuously evaluated and monitored for improvement opportunities					
5.9	All processes are continuously questioned if it is adding value					

6	**Employee Involvement**	**Strongly Disagree**	**Disagree**	**Neutral / Unsure**	**Agree**	**Strongly Agree**
6.1	Shop floor employees participate in problem solving					
6.2	Shop floor employees perform their own quality checks					
6.3	Shop floor employees fix minor quality problems as they occur					
6.4	Shop floor employees perform general maintenance of equipment					
6.5	Employees are recognised for going the extra mile and making superior quality improvement					
6.6	Employees are motivated to come up with improvement suggestions					
6.7	Employees are rewarded for learning new skills					
6.8	Sufficient cross functional training is provided to multi-skill employees					
6.9	All employees are adequately trained to perform their functions					
6.10	All employees are encouraged to assist across the different functions and work as a team					
6.11	All employees are encouraged to challenge the way they work					
6.12	Employees are encouraged to learn from mistakes so that we don't repeat them					

7	**Customer Focus**	**Strongly Disagree**	**Disagree**	**Neutral / Unsure**	**Agree**	**Strongly Agree**
7.1	We frequently are in close contact with our customers					
7.2	Customer surveys are used to elicit customer needs and "Voice Of Customer" information					
7.3	Our employees know our customers and competitors					
7.4	Our customers are directly involved in current and future product offerings					
7.5	We use customer requirements as the basis for quality improvement					
7.6	Our customers frequently share current and future demand information with our organisation					
7.7	We continuously build customer confidence and create a clear understanding of our market					

SECTION E – IMPROVEMENT TOOLS AND TECHNIQUES

Please select from list of quality improvement tools and techniques presented in the table below all of those that are commonly used in your organisation:

Mark appropriate selections with "X"			
Error Proofing (Poke-Yoke)		Control Chart	
Pareto Chart		Just In Time	
Process mapping		Run Charts	
Value Added Flowchart		Scatter Plot	
Corrective Action Matrix		Quality Function Deployment	
Failure Mode and Effect Analysis		Normal Probability Plot	
Spaghetti Diagrams		Root Cause Analysis	
Measurement System Analysis / Gage R&R		Fault Tree Analysis	
Trend Charts		Gantt Chart	
Capability Indices / Process Capability		Critical to Quality Analysis (CTQ)	
Cause and Effect Diagram (Fishbone)		Standardisation	
Histogram		Waste Analysis	
5-Why Analysis		Customer Surveys	
Regression Analysis		SIPOC	
Design of Experiments		House of Quality	
Hypothesis Testing		Check Sheet	
Kano Analysis		Control Plan	
Analysis of Variance		5S	
Brainstorming			
Other (please specify):			

END **THANK YOU.**

FACTOR ANALYSIS ANNEXURE C

Rotated component matrix

Section B - Lean Organisations	Component 1	2	3
1.5) On a scale of 1 – 5 how would you rate the level of management/leadership commitment within the organisation to drive, live and demonstrate Lean behaviour	0.919		
1.6) On a scale of 1 – 5 how would you rate the level of employee involvement to achieve the Lean goals.	0.871		
1.7) On a scale of 1 – 5 how would you rate the level of the employees understanding towards Lean and where the business is heading	0.898		
1.8) On a scale of 1 – 5 how would you rate the methods that the organisation has in place to continuously develop and sustain the Lean culture	0.886		

Section C - Six Sigma Organisations	**1**	**2**	**3**
1.5) On a scale of 1 – 5 how would you rate the level of management/leadership commitment within the organisation to drive, live and demonstrate Six Sigma behaviour	0.940		
1.6) On a scale of 1 – 5 how would you rate the level of employee involvement to achieve the Six Sigma goals	0.944		
1.7) On a scale of 1 – 5 how would you rate the level of the employees understanding towards Six Sigma and where the business is heading	0.940		
1.8) On a scale of 1 – 5 how would you rate the methods that the organisation has in place to continuously develop and sustain the Six Sigma culture	0.944		

Section D1 - Organisational Infrastructure	**1**	**2**	**3**
1.1) All processes and policies within the organisation are well defined and maintained	0.865		
1.2) The organisation’s strategies are focused on goals and results to achieve competitive advantage	0.854		
1.3) The organisation commits to modifying systems and structures to support business assurance	0.726		
1.4) The organisation respects and supports the diversity of different cultures	0.867		
1.5) A culture of continuous improvement is visible on the shop floor and throughout the organisation	0.844		

Section D2 - Management Commitment / Leadership	**1**	**2**	**3**
2.1) The management team knows how to build motivation in the organisation	0.742		
2.2) Management has arrangements to support skills, experience and competence retention	0.851		
2.3) Managers go to where the action takes place (Gemba)	0.872		
2.4) Management defines the appropriate roles and responsibilities within the organisation	0.877		
2.5) Management provides continuous feedback to employees on their performance	0.903		

Section D3 - Commitment to Quality	**1**	**2**	**3**
3.1) Top management (i.e. top executives and major department heads) assume responsibility for quality performance	0.820		
3.2) Top management provides personal leadership for quality products and quality improvements	0.894		
3.3) All employees are adequately trained on basic quality principles and statistical techniques	0.834		
3.4) Quality data (error rates, defect rates, scrap, defects, cost of quality) are available throughout the plant	0.799		
3.5) Quality data are used as tools to manage quality	0.745		
3.6) The organisation faces up to problems immediately as they arise and makes effective decisions	0.706		

Section D4 - Production Control	1	2	3
4.1) We use a pull production system in our manufacturing process	0.6	0.7	
4.2) Single piece flow of material is maintained between processes	0.8	0.4	
4.3) We use Kanban systems to signal for material requirements in each process	0.6	0.7	
4.4) The factory layout is divided into manufacturing cells that encompass product families with similar processing requirements	0.0	0.8	
4.5) The production schedule is directly linked with the rate of customer demand	0.0	0.8	
4.6) We use the SMED technique to provide rapid change-over of tooling and fixtures	0.4	0.7	
4.7) The seven forms of production waste (overproduction, waiting, transportation, processing, inventory, motion, defects) are identified and highlighted in our processes	0.4	0.5	
4.8) We practice the 5S tool to ensure that the organisations shop floors are well organised, clean and safe	0.7	0.0	
4.9) We have standard operating procedures for all processes	0.9	0.1	
4.10) Production is stopped immediately for every abnormality	0.7	0.4	

Section D5 - Process Improvement	1	2	3
5.1) "Poke-Yoke" devices are used in our organisation to minimize the chances of errors	0.754	0.103	
5.2) Clear process instructions are given to employees	-0.098	0.807	
5.3) All equipment and processes on the shop floor are under statistical process control	0.857	0.023	
5.4) Measures are in place to assess process performance and identify possible improvements projects	0.557	0.716	
5.5) All improvement projects are structured and undertaken systematically	0.620	0.374	
5.6) There is an appropriate infrastructure of improvement specialists in the organisation	0.756	0.336	
5.7) All significant process improvement decisions are based on facts that are gathered from statistical data	0.749	0.251	
5.8) The value stream is continuously evaluated and monitored for improvement opportunities	0.558	0.674	
5.9) All processes are continuously questioned if it is adding value	0.345	0.771	

Section D6 - Employee Involvement	1	2	3
6.1) Shop floor employees participate in problem solving	0.07	0.91	0.07
6.2) Shop floor employees perform their own quality checks	0.16	0.61	0.55
6.3) Shop floor employees fix minor quality problems as they occur	0.85	0.14	0.34
6.4) Shop floor employees perform general maintenance of equipment	0.39	0.62	0.25
6.5) Employees are recognised for going the extra mile and making superior quality improvement	0.93	0.13	0.16
6.6) Employees are motivated to come up with improvement suggestions	0.17	0.26	0.68
6.7) Employees are rewarded for learning new skills	0.54	0.56	0.30
6.8) Sufficient cross functional training is provided to multi-skill employees	0.38	0.50	0.51
6.9) All employees are adequately trained to perform their functions	0.44	0.02	0.67
6.10) All employees are encouraged to assist across the different functions and work as a team	0.00	0.76	0.25
6.11) All employees are encouraged to challenge the way they work	0.90	0.18	0.24
6.12) Employees are encouraged to learn from mistakes so that we don't repeat them	0.92	0.10	0.25

Section D7 - Customer Focus	1	2	3
7.1) We frequently are in close contact with our customers	0.327	0.743	
7.2) Customer surveys are used to elicit customer needs and "Voice Of Customer" information	0.912	0.175	
7.3) Our employees know our customers and competitors	0.821	0.296	
7.4) Our customers are directly involved in current and future product offerings	0.604	0.643	
7.5) We use customer requirements as the basis for quality improvement	0.792	0.220	
7.6) Our customers frequently share current and future demand information with our organisation	0.130	0.789	
7.7) We continuously build customer confidence and create a clear understanding of our market	0.223	0.881	

KRUSKAL WALLIS TEST ANNEXURE D

Section B - Lean Organisations	Chi-Square	df	Asymp. Sig.
1.5) On a scale of 1 – 5 how would you rate the level of management/leadership commitment within the organisation to drive, live and demonstrate Lean behaviour	0.544	1	0.461
1.6) On a scale of 1 – 5 how would you rate the level of employee involvement to achieve the Lean goals.	0.036	1	0.850
1.7) On a scale of 1 – 5 how would you rate the level of the employees understanding towards Lean and where the business is heading	4.425	1	0.035
1.8) On a scale of 1 – 5 how would you rate the methods that the organisation has in place to continuously develop and sustain the Lean culture	1.786	1	0.181

Section D1 - Organisational Infrastructure	Chi-Square	df	Asymp. Sig.
1.1) All processes and policies within the organisation are well defined and maintained	3.071	2	0.215
1.2) The organisation's strategies are focused on goals and results to achieve competitive advantage	0.380	2	0.827
1.3) The organisation commits to modifying systems and structures to support business assurance	2.831	2	0.243
1.4) The organisation respects and supports the diversity of different cultures	2.827	2	0.243
1.5) A culture of continuous improvement is visible on the shop floor and throughout the organisation	0.955	2	0.620

Section D2 - Management Commitment / Leadership	Chi-Square	df	Asymp. Sig.
2.1) The management team knows how to build motivation in the organisation	0.289	2	0.865
2.2) Management has arrangements to support skills, experience and competence retention	2.041	2	0.360
2.3) Managers go to where the action takes place (Gemba)	1.990	2	0.370
2.4) Management defines the appropriate roles and responsibilities within the organisation	1.269	2	0.530
2.5) Management provides continuous feedback to employees on their performance	1.720	2	0.423

Section D3 - Commitment to Quality	Chi-Square	df	Asymp. Sig.
3.1) Top management (i.e. top executives and major department heads) assume responsibility for quality performance	0.889	2	0.641
3.2) Top management provides personal leadership for quality products and quality improvements	4.008	2	0.135
3.3) All employees are adequately trained on basic quality principles and statistical techniques	0.629	2	0.730
3.4) Quality data (error rates, defect rates, scrap, defects, cost of quality) are available throughout the plant	15.493	2	0.000
3.5) Quality data are used as tools to manage quality	2.882	2	0.237
3.6) The organisation faces up to problems immediately as they arise and makes effective decisions	12.906	2	0.002

Section D4 - Production Control	Chi-Square	df	Asymp. Sig.
4.1) We use a pull production system in our manufacturing process	7.678	2	0.022
4.2) Single piece flow of material is maintained between processes	6.096	2	0.047
4.3) We use Kanban systems to signal for material requirements in each process	6.900	2	0.032
4.4) The factory layout is divided into manufacturing cells that encompass product families with similar processing requirements	2.139	2	0.343
4.5) The production schedule is directly linked with the rate of customer demand	2.960	2	0.228
4.6) We use the SMED technique to provide rapid change-over of tooling and fixtures	6.734	2	0.034
4.7) The seven forms of production waste (overproduction, waiting, transportation, processing, inventory, motion, defects) are identified and highlighted in our processes	6.463	2	0.040
4.8) We practice the 5S tool to ensure that the organisations shop floors are well organised, clean and safe	4.708	2	0.095
4.9) We have standard operating procedures for all processes	7.621	2	0.022
4.10) Production is stopped immediately for every abnormality	3.762	2	0.152

Section D5 - Process Improvement	Chi-Square	df	Asymp. Sig.
5.1) “Poke-Yoke” devices are used in our organisation to minimize the chances of errors	2.442	2	0.295
5.2) Clear process instructions are given to employees	11.542	2	0.003
5.3) All equipment and processes on the shop floor are under statistical process control	7.757	2	0.021
5.4) Measures are in place to assess process performance and identify possible improvements projects	4.333	2	0.115
5.5) All improvement projects are structured and undertaken systematically	3.005	2	0.223
5.6) There is an appropriate infrastructure of improvement specialists in the organisation	14.958	2	0.001
5.7) All significant process improvement decisions are based on facts that are gathered from statistical data	18.711	2	0.000
5.8) The value stream is continuously evaluated and monitored for improvement opportunities	4.649	2	0.098
5.9) All processes are continuously questioned if it is adding value	5.799	2	0.055

Section D6 - Employee Involvement	Chi-Square	df	Asymp. Sig.
6.1) Shop floor employees participate in problem solving	1.188	2	0.552
6.2) Shop floor employees perform their own quality checks	3.672	2	0.159
6.3) Shop floor employees fix minor quality problems as they occur	14.335	2	0.001
6.4) Shop floor employees perform general maintenance of equipment	6.520	2	0.038
6.5) Employees are recognised for going the extra mile and making superior quality improvement	13.759	2	0.001
6.6) Employees are motivated to come up with improvement suggestions	1.557	2	0.459
6.7) Employees are rewarded for learning new skills	1.135	2	0.567
6.8) Sufficient cross functional training is provided to multi-skill employees	5.012	2	0.082
6.9) All employees are adequately trained to perform their functions	6.931	2	0.031
6.10) All employees are encouraged to assist across the different functions and work as a team	0.631	2	0.730
6.11) All employees are encouraged to challenge the way they work	15.996	2	0.000
6.12) Employees are encouraged to learn from mistakes so that we don’t repeat them	19.357	2	0.000

Section D7 - Customer Focus	Chi-Square	df	Asymp. Sig.
7.1) We frequently are in close contact with our customers	6.789	2	0.034
7.2) Customer surveys are used to elicit customer needs and “Voice Of Customer” information	2.037	2	0.361
7.3) Our employees know our customers and competitors	3.667	2	0.160
7.4) Our customers are directly involved in current and future product offerings	4.130	2	0.127
7.5) We use customer requirements as the basis for quality improvement	1.018	2	0.601
7.6) Our customers frequently share current and future demand information with our organisation	8.276	2	0.016
7.7) We continuously build customer confidence and create a clear understanding of our market	5.921	2	0.052

RANKS

Section B - Lean Organisations	Type of Practice	N	Mean Rank
1.5) On a scale of 1 – 5 how would you rate the level of management/leadership commitment within the organisation to drive, live and demonstrate Lean behaviour	Lean	9	9.50
	Both	11	11.32
	Total	20	
1.6) On a scale of 1 – 5 how would you rate the level of employee involvement to achieve the Lean goals.	Lean	9	10.28
	Both	11	10.68
	Total	20	
1.7) On a scale of 1 – 5 how would you rate the level of the employees understanding towards Lean and where the business is heading	Lean	9	7.89
	Both	11	12.64
	Total	20	
1.8) On a scale of 1 – 5 how would you rate the methods that the organisation has in place to continuously develop and sustain the Lean culture	Lean	9	8.67
	Both	11	12.00
	Total	20	

Section C - Six Sigma Organisations	Type of Practice	N	Mean Rank
1.5) On a scale of 1 – 5 how would you rate the level of management/leadership commitment within the organisation to drive, live and demonstrate Six Sigma behaviour	Both	10	5.50
	Total	10[a]	
1.6) On a scale of 1 – 5 how would you rate the level of employee involvement to achieve the Six Sigma goals	Both	10	5.50
	Total	10[a]	
1.7) On a scale of 1 – 5 how would you rate the level of the employees understanding towards Six Sigma and where the business is heading	Both	10	5.50
	Total	10[a]	
1.8) On a scale of 1 – 5 how would you rate the methods that the organisation has in place to continuously develop and sustain the Six Sigma culture	Both	10	5.50
	Total	10[a]	

Section D1 - Organisational Infrastructure	Type of Practice	N	Mean Rank
1.1) All processes and policies within the organisation are well defined and maintained	Lean	9	18.44
	Both	11	18.68
	Neither	12	13.04
	Total	32	
1.2) The organisation's strategies are focused on goals and results to achieve competitive advantage	Lean	9	16.33
	Both	11	17.73
	Neither	12	15.50
	Total	32	
1.3) The organisation commits to modifying systems and structures to support business assurance	Lean	9	18.28
	Both	11	18.77
	Neither	12	13.08
	Total	32	
1.4) The organisation respects and supports the diversity of different cultures	Lean	9	16.44
	Both	11	19.77
	Neither	12	13.54
	Total	32	
1.5) A culture of continuous improvement is visible on the shop floor and throughout the organisation	Lean	9	17.89
	Both	11	17.50
	Neither	12	14.54
	Total	32	

Section D2 - Management Commitment / Leadership	Type of Practice	N	Mean Rank
2.1) The management team knows how to build motivation in the organisation	Lean	9	17.83
	Both	11	15.82
	Neither	12	16.13
	Total	32	
2.2) Management has arrangements to support skills, experience and competence retention	Lean	9	14.61
	Both	11	19.64
	Neither	12	15.04
	Total	32	
2.3) Managers go to where the action takes place (Gemba)	Lean	9	15.50
	Both	11	19.45
	Neither	12	14.54
	Total	32	
2.4) Management defines the appropriate roles and responsibilities within the organisation	Lean	9	15.44
	Both	11	18.86
	Neither	12	15.13
	Total	32	
2.5) Management provides continuous feedback to employees on their performance	Lean	9	16.44
	Both	11	19.05
	Neither	12	14.21
	Total	32	

Section D3 - Commitment to Quality	Type of Practice	N	Mean Rank
3.1) Top management (i.e. top executives and major department heads) assume responsibility for quality performance	Lean	9	17.33
	Both	11	17.91
	Neither	12	14.58
	Total	32	
3.2) Top management provides personal leadership for quality products and quality improvements	Lean	9	15.89
	Both	11	20.55
	Neither	12	13.25
	Total	32	
3.3) All employees are adequately trained on basic quality principles and statistical techniques	Lean	9	16.17
	Both	11	18.14
	Neither	12	15.25
	Total	32	
3.4) Quality data (error rates, defect rates, scrap, defects, cost of quality) are available throughout the plant	Lean	9	13.78
	Both	11	24.59
	Neither	12	11.13
	Total	32	
3.5) Quality data are used as tools to manage quality	Lean	9	16.94
	Both	11	19.59
	Neither	12	13.33
	Total	32	
3.6) The organisation faces up to problems immediately as they arise and makes effective decisions	Lean	9	12.28
	Both	11	24.05
	Neither	12	12.75
	Total	32	

Section D4 - Production Control	Type of Practice	N	Mean Rank
4.1) We use a pull production system in our manufacturing process	Lean	9	20.67
	Both	11	19.18
	Neither	12	10.92
	Total	32	
4.2) Single piece flow of material is maintained between processes	Lean	9	20.72
	Both	11	18.36
	Neither	12	11.63
	Total	32	
4.3) We use Kanban systems to signal for material requirements in each process	Lean	9	20.11
	Both	11	19.36
	Neither	12	11.17
	Total	32	
4.4) The factory layout is divided into manufacturing cells that encompass product families with similar processing requirements	Lean	9	17.67
	Both	11	18.73
	Neither	12	13.58
	Total	32	
4.5) The production schedule is directly linked with the rate of customer demand	Lean	9	20.28
	Both	11	16.59
	Neither	12	13.58
	Total	32	
4.6) We use the SMED technique to provide rapid change-over of tooling and fixtures	Lean	9	20.00
	Both	11	19.41
	Neither	12	11.21
	Total	32	
4.7) The seven forms of production waste (overproduction, waiting, transportation, processing, inventory, motion, defects) are identified and highlighted in our processes	Lean	9	20.67
	Both	11	18.27
	Neither	12	11.75
	Total	32	
4.8) We practice the 5S tool to ensure that the organisations shop floors are well organised, clean and safe	Lean	9	19.83
	Both	11	18.50
	Neither	12	12.17
	Total	32	
4.9) We have standard operating procedures for all processes	Lean	9	17.44
	Both	11	21.45
	Neither	12	11.25
	Total	32	
4.10) Production is stopped immediately for every abnormality	Lean	9	20.44
	Both	11	17.18
	Neither	12	12.92
	Total	32	

Section D5 - Process Improvement	Type of Practice	N	Mean Rank
5.1) "Poke-Yoke" devices are used in our organisation to minimize the chances of errors	Lean	9	17.11
	Both	11	19.32
	Neither	12	13.46
	Total	32	
5.2) Clear process instructions are given to employees	Lean	9	22.28
	Both	11	19.27
	Neither	12	9.63
	Total	32	
5.3) All equipment and processes on the shop floor are under statistical process control	Lean	9	12.83
	Both	11	22.68
	Neither	12	13.58
	Total	32	
5.4) Measures are in place to assess process performance and identify possible improvements projects	Lean	9	17.78
	Both	11	19.95
	Neither	12	12.38
	Total	32	
5.5) All improvement projects are structured and undertaken systematically	Lean	9	14.67
	Both	11	20.36
	Neither	12	14.33
	Total	32	
5.6) There is an appropriate infrastructure of improvement specialists in the organisation	Lean	9	15.06
	Both	11	24.23
	Neither	12	10.50
	Total	32	
5.7) All significant process improvement decisions are based on facts that are gathered from statistical data	Lean	9	15.94
	Both	11	24.77
	Neither	12	9.33
	Total	32	
5.8) The value stream is continuously evaluated and monitored for improvement opportunities	Lean	9	18.22
	Both	11	19.68
	Neither	12	12.29
	Total	32	
5.9) All processes are continuously questioned if it is adding value	Lean	9	20.61
	Both	11	18.23
	Neither	12	11.83
	Total	32	

Section D6 - Employee Involvement	Type of Practice	N	Mean Rank
6.1) Shop floor employees participate in problem solving	Lean	9	18.72
	Both	11	16.82
	Neither	12	14.54
	Total	32	
6.2) Shop floor employees perform their own quality checks	Lean	9	17.50
	Both	11	19.64
	Neither	12	12.88
	Total	32	
6.3) Shop floor employees fix minor quality problems as they occur	Lean	9	12.44
	Both	11	24.50
	Neither	12	12.21
	Total	32	
6.4) Shop floor employees perform general maintenance of equipment	Lean	9	18.83
	Both	11	20.32
	Neither	12	11.25
	Total	32	
6.5) Employees are recognised for going the extra mile and making superior quality improvement	Lean	9	13.72
	Both	11	24.32
	Neither	12	11.42
	Total	32	
6.6) Employees are motivated to come up with improvement suggestions	Lean	9	17.67
	Both	11	18.27
	Neither	12	14.00
	Total	32	
6.7) Employees are rewarded for learning new skills	Lean	9	16.17
	Both	11	18.73
	Neither	12	14.71
	Total	32	
6.8) Sufficient cross functional training is provided to multi-skill employees	Lean	9	17.44
	Both	11	20.36
	Neither	12	12.25
	Total	32	
6.9) All employees are adequately trained to perform their functions	Lean	9	15.39
	Both	11	21.86
	Neither	12	12.42
	Total	32	
6.10) All employees are encouraged to assist across the different functions and work as a team	Lean	9	16.22
	Both	11	18.14
	Neither	12	15.21
	Total	32	
6.11) All employees are encouraged to challenge the way they work	Lean	9	13.39
	Both	11	24.82
	Neither	12	11.21
	Total	32	
6.12) Employees are encouraged to learn from mistakes so that we don't repeat them	Lean	9	12.28
	Both	11	25.73
	Neither	12	11.21
	Total	32	

Section D7 - Customer Focus	Type of Practice	N	Mean Rank
7.1) We frequently are in close contact with our customers	Lean	9	21.00
	Both	11	18.27
	Neither	12	11.50
	Total	32	
7.2) Customer surveys are used to elicit customer needs and “Voice Of Customer” information	Lean	9	17.89
	Both	11	18.50
	Neither	12	13.63
	Total	32	
7.3) Our employees know our customers and competitors	Lean	9	18.22
	Both	11	19.27
	Neither	12	12.67
	Total	32	
7.4) Our customers are directly involved in current and future product offerings	Lean	9	18.89
	Both	11	19.00
	Neither	12	12.42
	Total	32	
7.5) We use customer requirements as the basis for quality improvement	Lean	9	17.61
	Both	11	17.82
	Neither	12	14.46
	Total	32	
7.6) Our customers frequently share current and future demand information with our organisation	Lean	9	22.89
	Both	11	16.68
	Neither	12	11.54
	Total	32	
7.7) We continuously build customer confidence and create a clear understanding of our market	Lean	9	21.33
	Both	11	17.32
	Neither	12	12.13
	Total	32	

KOLMOGOROV-SMIRNOV TEST OF NORMALITY ANNEXURE E

Section B - Lean Organisations	N	Normal Parameters[a,b]		Most Extreme Differences			Kolmogorov-Smirnov Z	Asymp. Sig. (2-tailed)
		Mean	Std. Deviation	Absolute	Positive	Negative		
Question 1.5	20	3.50	1.192	0.313	0.313	-0.246	1.398	0.040
Question 1.6	20	2.70	0.923	0.427	0.273	-0.427	1.911	0.001
Question 1.7	20	2.60	0.821	0.387	0.263	-0.387	1.731	0.005
Question 1.8	20	3.30	1.129	0.305	0.305	-0.184	1.363	0.049

Section C - Six Sigma Organisations	N	Normal Parameters[a,b]		Most Extreme Differences			Kolmogorov-Smirnov Z	Asymp. Sig. (2-tailed)
		Mean	Std. Deviation	Absolute	Positive	Negative		
Question 1.5	10	2.70	0.823	0.342	0.258	-0.342	1.082	0.192
Question 1.6	10	2.60	0.699	0.416	0.284	-0.416	1.317	0.062
Question 1.7	10	2.30	0.823	0.302	0.198	-0.302	.956	0.320
Question 1.8	10	2.40	0.699	0.305	0.216	-0.305	.963	0.312

Section D1 - Organisational Infrastructure	N	Normal Parameters[a,b]		Most Extreme Differences			Kolmogorov-Smirnov Z	Asymp. Sig. (2-tailed)
		Mean	Std. Deviation	Absolute	Positive	Negative		
Question 1.1	32	2.78	1.362	0.283	0.248	-0.283	1.603	0.012
Question 1.2	32	2.72	1.442	0.282	0.258	-0.282	1.593	0.012
Question 1.3	32	3.38	1.454	0.243	0.234	-0.243	1.376	0.045
Question 1.4	32	3.31	1.306	0.249	0.249	-0.214	1.407	0.038
Question 1.5	32	2.81	1.230	0.279	0.211	-0.279	1.580	0.014

Section D2 - Management Commitment / Leadership	N	Normal Parameters[a,b]		Most Extreme Differences			Kolmogorov-Smirnov Z	Asymp. Sig. (2-tailed)
		Mean	Std. Deviation	Absolute	Positive	Negative		
Question 1.1	32	2.78	1.362	0.252	0.217	-0.252	1.426	0.034
Question 1.2	32	3.16	1.417	0.216	0.200	-0.216	1.222	0.101
Question 1.3	32	2.72	1.442	0.282	0.258	-0.282	1.593	0.012
Question 1.4	32	2.94	1.294	0.294	0.214	-0.294	1.665	0.008
Question 1.5	32	2.78	1.289	0.265	0.198	-0.265	1.501	0.022

Section D3 - Commitment to Quality	N	Normal Parameters[a,b]		Most Extreme Differences			Kolmogorov-Smirnov Z	Asymp. Sig. (2-tailed)
		Mean	Std. Deviation	Absolute	Positive	Negative		
Question 1.1	32	2.78	1.289	0.234	0.167	-0.234	1.324	0.060
Question 1.2	32	3.16	1.273	0.256	0.256	-0.208	1.446	0.030
Question 1.3	32	2.72	1.250	0.276	0.228	-0.276	1.564	0.015
Question 1.4	32	3.19	1.378	0.306	0.306	-0.250	1.729	0.005
Question 1.5	32	2.84	1.221	0.238	0.184	-0.238	1.349	0.053
Question 1.6	32	3.28	1.397	0.289	0.289	-0.266	1.636	0.009

Section D4 - Production Control	N	Normal Parameters[a,b]		Most Extreme Differences			Kolmogorov-Smirnov Z	Asymp. Sig. (2-tailed)
		Mean	Std. Deviation	Absolute	Positive	Negative		
Question 1.1	32	2.59	1.365	0.254	0.254	-0.211	1.435	0.033
Question 1.2	32	2.91	1.254	0.249	0.186	-0.249	1.406	0.038
Question 1.3	32	2.69	1.355	0.237	0.237	-0.216	1.343	0.054
Question 1.4	32	2.84	1.273	0.268	0.208	-0.268	1.514	0.020
Question 1.5	32	2.81	1.230	0.279	0.211	-0.279	1.580	0.014
Question 1.6	32	2.72	1.350	0.235	0.211	-0.235	1.329	0.058
Question 1.7	32	3.69	0.965	0.346	0.217	-0.346	1.956	0.001
Question 1.8	32	4.00	1.016	0.250	0.162	-0.250	1.414	0.037
Question 1.9	32	3.28	1.054	0.261	0.261	-0.145	1.479	0.025
Question 1.10	32	3.19	1.030	0.260	0.260	-0.147	1.469	0.027

Section D5 - Process Improvement	N	Normal Parameters[a,b]		Most Extreme Differences			Kolmogorov-Smirnov Z	Asymp. Sig. (2-tailed)
		Mean	Std. Deviation	Absolute	Positive	Negative		
Question 1.1	32	2.72	1.224	0.196	0.159	-0.196	1.109	0.171
Question 1.2	32	3.44	1.413	0.217	0.189	-0.217	1.229	0.098
Question 1.3	32	2.59	1.241	0.215	0.215	-0.153	1.217	0.103
Question 1.4	32	2.72	1.224	0.227	0.170	-0.227	1.286	0.073
Question 1.5	32	2.72	1.250	0.160	0.155	-0.160	.904	0.388
Question 1.6	32	3.16	1.347	0.305	0.305	-0.227	1.724	0.005
Question 1.7	32	3.22	1.385	0.311	0.311	-0.245	1.757	0.004
Question 1.8	32	2.84	1.322	0.278	0.231	-0.278	1.571	0.014
Question 1.9	32	2.72	1.420	0.262	0.262	-0.254	1.482	0.025

Section D6 - Employee Involvement	N	Normal Parameters[a,b]		Most Extreme Differences			Kolmogorov-Smirnov Z	Asymp. Sig. (2-tailed)
		Mean	Std. Deviation	Absolute	Positive	Negative		
Question 1.1	32	2.78	1.313	0.261	0.225	-0.261	1.475	0.026
Question 1.2	32	2.78	1.362	0.283	0.248	-0.283	1.603	0.012
Question 1.3	32	3.22	1.362	0.283	0.283	-0.248	1.603	0.012
Question 1.4	32	2.81	1.256	0.203	0.179	-0.203	1.148	0.144
Question 1.5	32	3.16	1.298	0.282	0.282	-0.204	1.597	0.012
Question 1.6	32	2.81	1.256	0.247	0.207	-0.247	1.396	0.040
Question 1.7	32	2.50	1.218	0.172	0.172	-0.159	.974	0.299
Question 1.8	32	2.72	1.326	0.271	0.215	-0.271	1.531	0.018
Question 1.9	32	2.84	1.394	0.297	0.220	-0.297	1.678	0.007
Question 1.10	32	2.81	1.330	0.251	0.195	-0.251	1.422	0.035
Question 1.11	32	3.28	1.397	0.289	0.289	-0.266	1.636	0.009
Question 1.12	32	3.28	1.397	0.289	0.289	-0.266	1.636	0.009

Section D7 - Customer Focus	N	Normal Parameters[a,b]		Most Extreme Differences			Kolmogorov-Smirnov Z	Asymp. Sig. (2-tailed)
		Mean	Std. Deviation	Absolute	Positive	Negative		
Question 1.1	32	3.38	1.129	0.318	0.318	-0.206	1.797	0.003
Question 1.2	32	2.72	1.143	0.285	0.184	-0.285	1.611	0.011
Question 1.3	32	3.16	0.954	0.218	0.159	-0.218	1.233	0.096
Question 1.4	32	3.16	1.247	0.269	0.269	-0.212	1.519	0.020
Question 1.5	32	2.72	1.198	0.280	0.206	-0.280	1.586	0.013
Question 1.6	32	3.47	1.344	0.248	0.199	-0.248	1.402	0.039
Question 1.7	32	3.34	1.004	0.306	0.194	-0.306	1.731	0.005