Application of Digital Technology in TQM Business Processes

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Abstract

Recent developments in manufacturing has advanced leading to organizations implementing digitalization to optimize and improve on their processes to meet customer demand. TQM has globally become best practice in various industries by bridging the gap to interpret the exact customer requirements to meeting the actual expectations. Quality management remains the priority in meeting every customer expectation, the role of total quality management is getting tougher and focused on optimizing processes while digital technology can positively impact company development. This research study aims to enhance the business function challenges within the overall organization, incorporating the functional departments and its sub-functions. The DMAIC (Define, Measure, Analyze, Improve and Control) methodology approach is used to collect data by using sequencing steps and time studies. A case study is used as the main data collection source to meet the objective of this research study. The proposed results indicate that processes that are interdependent can be configured with effect of variation in reducing processing times within business processes. This results to improved processes, reduced lead time and reduced level of human error. The purpose of the study is to prove that applying digital technology to TQM business processes can yield positive results. Based on this research study, it is found that digital technology is able to reflect positive results which may improve business processes of TQM in various ways. By applying digital technology processes are enhanced to perform at the maximum functional level.

Abbreviations

CAPEX	Capital expenditures
CAR	Corrective Action Report
COC	Certificate of Conformance
COQ	Cost of Quality
DMAIC	Define Measure Analyze Improve Control
ERP	Enterprise Resource Planning
MES	Manufacturing Execution System
NCR	Non-Conformance Report
PDCA	Plan Do Check Act
PFMEA	Process Failure Mode Effect and Analysis
SCM	Supply Chain Management
SME	Small Medium-sized Enterprises
TPM	Total Productive Maintenance
TQM	Total Quality Management

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Chapter I: Introduction

1.1 Rationale of the study

TQM (Total Quality Management) has become the world`s dominant quality solution in improving quality systems and continuous improvement. Industries are using the ISO 9001 standard for compliance, while other organizations practice TQM to further develop and sustain the organizational strategic goals and income growth. The revelation on the application of a quality management system and ISO 9001 has by far been the quality requirement from customers and regulators as evidence of commitment and ability of every organization. Various industries have implemented TQM to advance their quality systems in order to control and better the organizational culture.

Competition within industries indicated the importance of customer satisfaction for corporate profitability and survival, where quality has become the key factor for the survival and competitiveness of a business [1]. Currently all industries have become competitive. According to Hendricks and Singhal [2], firms that have effectively implemented Total Quality Management outperform firms within the same level caliber that have not implemented total quality management in terms of cost, income, profits, total assets, number of resources and capital outlay. Aleksandrova, Vasiliev, Letuchev [3], emphasized on the integration of quality management methods with modern information technology that it may ensure competitiveness in existing organizations. Total Quality Management has only been applied in manufacturing industries but has over the years evolved into diverse business sectors to gain reputation as the main factor to achieve competitive advantage.

Total Quality Management has the ability to adopt and diversify any business framework by translating and responding to the needs of the relevant stakeholders [8]. TQM approach is used in organizations as a tool to serve customer needs and enhancing profits to their stakeholders. The success of attending to these needs may require the use of a computer to improve information flow.

Total Quality Management is a conventional term which compromises of principles and practices, it's also known to a philosophy, addressing not only the quality management but the management of quality. Various studies from quality gurus to individual researchers have established a constructive relationship between TQM and the enhanced performance. The primary focus for TQM is to increase efficiency and improve processes, that are implemented within manufacturing organizations [4].

1.2 Problem Statement

Quality Management remains the top priority in meeting customer demand. As the needs and expectations of customers increases, the quality of the product requires to improve to meet customer satisfaction. Customer satisfaction is profoundly influenced by customer expectation and the gap between the actual quality and the expected quality by the customer, is a direct forecaster to customer satisfaction [5].

Total Quality Management is intended to bridge the gap to interpret the exact customer requirement to meet the actual expectation. TQM has now become the prospect for companies to gain knowledge and strategies on how to evolve with the needs and expectations of their customers. The concept has become the “natural candidate” in strategic planning also project advancements and currently organizations are now using the Total Quality Management structure to change processes [6].

The development of quality in industries not only focuses on supplying customers but making sure that the customer is satisfied on the product or service rendered. Customer satisfaction has become a challenge in the African continent; outsourcing from other countries has become the primary solution to saving costs and getting quality service. The four elements of service quality dimensions namely; consistency, dependability and timeliness, tend to be significant to maximizing customer satisfaction. Researches define quality as portrayed using multidimensional criteria:” performance, features, reliability, conformance, durability, serviceability, aesthetics, and perceived quality” [7].

The evolution of small and big enterprises has drawn to use Total Quality Management business process to strategize, optimizing of complex business systems and models. Quality control is still perceived as the only effective tool to solve problems, addressing quality concerns, but has not been more effective unless supported by implementation of TQM [3]. The focus on quality data and reporting mainly depends the business process and the expected data. While data collections may constitute as the main challenge when using manual systems and depending on human to manually write the data and transfer the data to a digital model. The outline of modern capabilities is to ensure the transfer data and information flow to be accurate and reliable.

1.3 Research Questions

Based on the background of the study as well as the research problem discussed in the preceding section, this study will be guided by three major research questions:

a. What is the international global practice of Total Quality Management and what are TQM functions within an organization?

b. What is the relationship between digital technology and TQM functions in different organizational sectors?

c. How is digital technology applied in a TQM business process within a manufacturing firm?

This study contributes to understanding Total Quality Management functions and the importance of applying digital technology as a support system. This benefit organizations to manage resources in a significant manner as well as sustaining organizational competence and performance.

1.4 Objective of Study

The objective of the study is to help production industries to successfully apply digital technology to support Total Quality Management in business processes. The focus on data collection and capturing live data is still a challenging factor that many organizations are facing in the manufacturing industry. The study aims to realize digital technology benefits, eliminate manual data capturing and accelerate information that affects TQM business processes.

The research paper focuses on generating knowledge from existing industries that have applied different TQM business processes and identified the need for integrating business functions into one configured digital technology system.

1.5 Summary of Chapters

Chapter 1 Introduction

This chapter describes the notion of Total Quality Management history and knowledge from majority of researchers in the Total Quality Management field, where they seek to find models and theories on continuous improvement. The section also gives TQM history from the quality gurus.

Chapter 2 Literature Review

This chapter presents the relevant literature on Total Quality Management and its functions. This is realized through a model summarizing the overall integration of TQM and its functions, with the inputs and outputs and digital technology. This section provides the critical discussion on the Total Quality Management concept and how it is applied in different business processes. The review also shows the benefit of integrating Total Quality Management and digital technology.

Chapter 3 Methodology

This chapter provides the frameworks of the methodology used for this research. This chapter discusses the research methods and the research design. Discussion on the methods selected, why it is selected, and how it influences the desired outcome of this research questions.

Chapter 4 Results and Discussions

The chapter covers the integration of business processes and applying digital technology in a production environment at ABC Manufacturing Company. A simulation of current and optimized results is presented. All the achievements of the simulated model are presented in this chapter and discussed into detail. This chapter also goes into detail on how the results of the research is achieved and how they can be carried through to optimize the current processes.

Chapter 5 Conclusion

This chapter reviews the research achievement set objectives of the study. Describing how digital technology may be applied to TQM functions, how the integration may be used as a tool to optimize business processes within in an organization. This chapter also illustrates the future research areas.

Chapter 2: Literature Review

2.1 Introduction

This chapter reviews the concepts of Total Quality Management, by assessing various aspects on how TQM is applied in manufacturing business processes. The chapter also reviews the framework of Total Quality Management principles and their functions. Relating structure principles interface with inputs and outputs within a business process. Finally, the literature gives an overview on the integration of TQM principles in a business process and digital technology, see Figure 1.

Key words: TQM, Business processes, Digital technology, TQM Principles

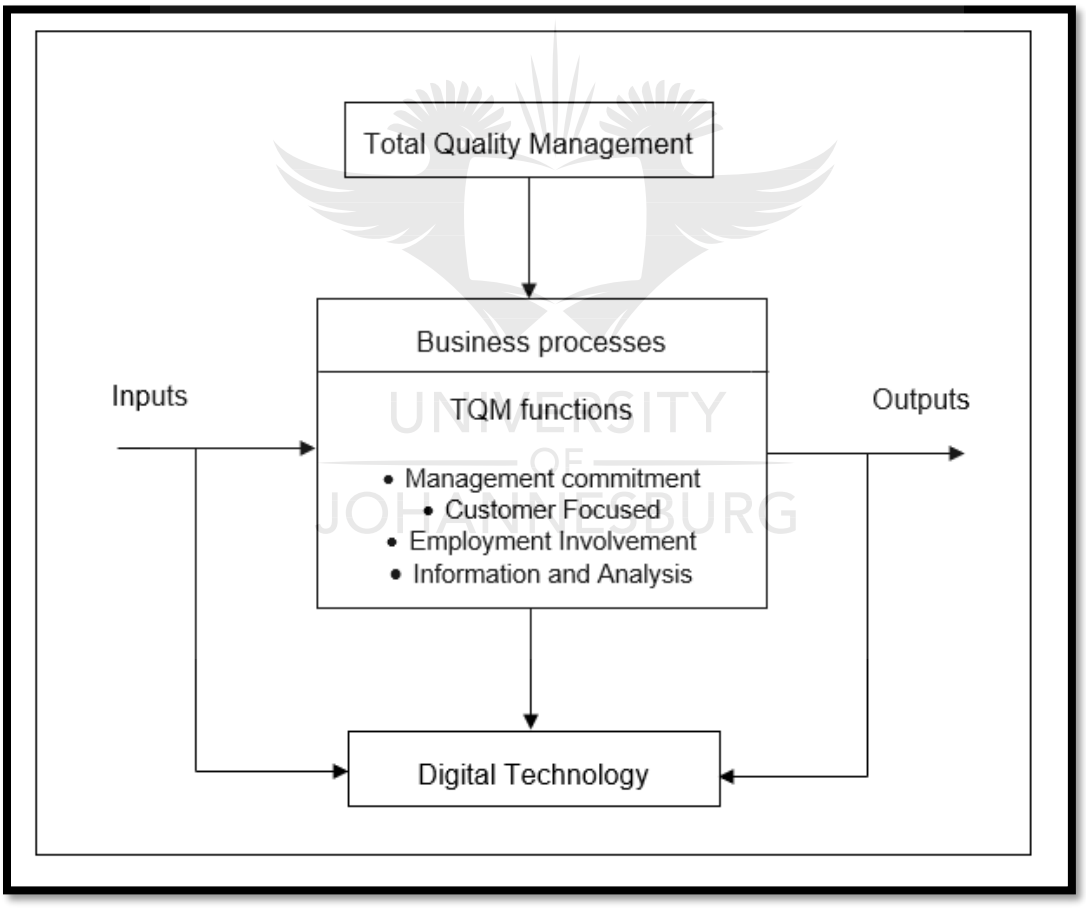


Figure 1: Integrating TQM framework and Digital Technology

Source: Author`s compilation

2.2 Total Quality Management

In late 1970 and early 1980 Total Quality Management primary emerged in the manufacturing industry to revitalize strategic focus on customer fulfillment and involving various parties to improve products, processes, environment, and cultural surrounding work responsibilities [8]. The development of TQM is a result of global competition, while quality management becomes an umbrella for diversified concepts, production tools and methods [9]. Researchers define Total Quality Management as a cost reduction tool and not a quality improvement tool in a “quality” context [4].

According to Tabibzadeh and Freil [10], emphasis on TQM is based on clear links to its customers and organizational objectives, which contribute to the well-defined improvement quality measures, using of scientific process and tools , managed teamwork, decision making that is driven by real time data, and keeping record of all that is archived and pursued. While Pambreni, Khatibl, Azam and Tham [11], describe total quality to be orientated with a business approach which aims to maximize organizational competitiveness in implementing continuous improvement of based on quality of product, service, resources, process and environmental needs. Organizations use data as the main source of information , evaluating the quality of historical data which is real time data with integrity on accuracy, complete ness and consistency [12].

Total Quality Management is viewed as the key competitive factor by many critics. Managers see TQM as a an important tool for integrating quality and its strategic impact, for some TQM may not be seen or accepted as a critical strategic tool resulting to radical businesses apart [13]. The view of different authors proves the wideness and evolution on knowledge base on Total Quality Management concepts and applications. Senior managers of organizations that have adapted TQM have a deeper understanding on the need to developing long term goals to innovate development strategies in order to make TQM more compatible [14].

Departmental silos has always been a challenge for most companies, in business context many functional departments work well and proficient with one another but not with other departments, as a result information sharing has become complicated and not easy to manage between other departments [15]. According to Koilakuntla, Patyal, Modgali and Ekkuluri [16], TQM has a mandate to join departments (Sales, Finance, Engineering, Human Resource, Design) to meeting customer requirements and to meet set goals and objectives of the organizations. Organizations that

successfully work together as constructive teams which results in breaking silos and encouraging departments to support one another.

2.2.1 Philosophies, Methods and Principles of Quality Gurus

Organizations aim to implement TQM based on the recognized teachings “quality gurus” such as Deming, Crosby and Juran. The mentioned authors emphasize the importance of quality and the impact on organizations in every field. This section elaborates on the origin of Total Quality Management from the quality gurus and to gain from their knowledge on what they have contributed to the development of TQM.

Total Quality Management has become the standard practice for both product and service industries. It has evolved over the years and the contribution from the quality gurus has created a good platform for organizations to look at quality in a different way. TQM today is based on the knowledge and studies that have created a foundation in the quality field. Table 1 provides insight on the contribution of the TQM quality gurus.

TQM gurus	Main quality contribution
W. Edward Deming	- Reiterated management’s responsibility for quality. - Developed “14 Points” to steer organizations in quality improvement. (refer to Deming, 1986 [17])
Joseph M. Juran	- Describing quality as “fitness for use”. - Emphasize on the involvement of individual employees in quality improvement and established concept of cost of quality (COQ). (refer to Juran, 1986 [18])
Armand V. Feigenbaum	- Emphasized a total system approach to quality. - Introduced concept of total quality control. (see Feigenbaum 1986)
Philip B. Crosby	- Invented phrase “quality is free”. - Introduced concept of zero defects (see Crosby, 1979).
Genichi Taguchi	- Focused on product/service design quality. - Originated the idea of quality loss on product from the time it was created quality loss function. (see Taguchi, 1999)
Kaoru Ishikawa	- Initiated quality circles and cause-and-effect diagrams. - Encouraged concept of “internal customer” (see Ishikawa, 1985)

Table 1: TQM Gurus and their main quality contributions

Source: Author`s compilation

W. Edwards Deming Principles

Deming has been named “the father of the Quality Management movement”, and has worked as a statistician in USA, Western Electric Company [19]. Quality guru Deming has developed theories and methods that have been applied in various countries during TQM implementation. According to Deming [20], TQM may be seen as a never-ending cycle, of progressing in the system where production transforms into advancing better performance and quality standards for a specific product. Deming has listed 14 points (Figure 2) as the important TQM principles which management need to practice [17].

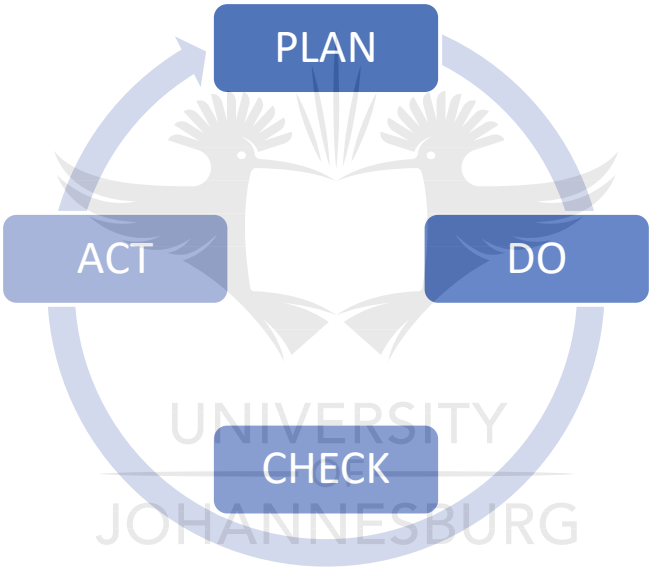


Figure 2: PDCA Cycle Diagram

Source: Author`s compilation

Deming developed the PDCA (Plan Do Check Act) cycle ,Figure 3**,** also called the Deming cycle or problem solving approach, which is based on the knowledge of believing that before initiating any activity planning is vital, where a proper planning dictates the necessary measures and control to structure for a successful outcome.

It is perceived as the focus for ensuring successful management processes, also known as the EQAVET cycle (Planning – Implementation – Evaluation – Review) [21]. Working as a management tool which may also be used by employees to reflect a process outcome and feedback.

Plan: Recognizing priorities and planning for improvement
Do: This is the implementation of the process
Check: Validation, measuring and analyzing results after implementation
Act: Implementation of best practice from validating outcome

1.Develop constancy of purpose	Relating to continuous improvement of a product or service, with aim to remain competitive, innovate on current market and bring in more business
2. Adaptation of new knowledge and philosophy	It is management responsibility to lead and adopt new knowledge and philosophies. Ensuring that every everything remains with in a set time, ensuring 100% quality compliance and performance with regards to workmanship
3. Achieve quality compliance	Eliminating inspection in a way to allow everyone to achieve top quality. Building a quality product that during production there are control measure that will not allow for any defect, this may also be archived by using statistical measure
4. Eliminate formalities of awarding businesses	Reducing the number of external providers but choosing to work with suppliers whom the organization will build a long-term relationship, extending trust and not compromising loyalty. This may result in organizations saving cost.
5. Continually improve systems	Continually put effort to improve on every activity in an organization, improving quality and increased productivity to see a reduction in cost. Management is responsible to ensure that every process or activity is always review and validated
6. Emphasis on training and on job training	Conduct training on TQM techniques for all employees this may also include management. Training is beneficial to organizations in terms of development and growth of an organization
7. Encourage and practice leadership	Leadership is aimed at mentoring and encouraging employees to excel in their job responsibilities. This action will benefit the organizations as there will be better support and communication between employees and management
8.Eliminate fear	Employees felling inferior will always have a negative impact, where employees do not voice out on concerning issues relating factors that affect their work performance. Employees need to be confident to voice out issues and feel safe to report matters to management
9. Dissolve silos between departments	Braking silos and barriers between departments. Encouraging teamwork between departments. Management encouraging team building activities for employees to engage more.
10. Drive out slogans, exhortations and pressure on targets	Slogans and pressure create frustrations and uncertainty to employees, this will mostly happen when management fail to provide what is required for them to carry out their duties
11. Eliminate numerical targets	Eliminating numerical targets that confuse employees and management, over limitations of continually improving on productivity and quality.
12. Eliminate barriers	Employees should continuously acquire new knowledge and more training. This initiative will help organizations to focus more on developing people and empowering people to not feel redundant.
13. Introduce a programs	Remove the annual employee ratings or systems used to measure merit
14. Strive to accomplish transformation	Top management commitment needs to continually improve in quality and productivity. Setting goals and objectives to fulfill organizational success

Figure 3: Deming 14 points, TQM principles for management

Source: Deming WE, *[17]*

Philip B Crosby Guide

Quality has become the vital concept leading to need and requirement to always keep customers happy and satisfied. Crosby is focused on the aim of quality representing , meeting customer needs and being able to translate customer requirements that measure the characteristic of the product or service [19]. Crosby is well known for two well-known concepts that are used today in many organizations.

1. “Do it right the first time”
2. “Zero Defects”

These concepts are a guide of ensuring that management take responsibility and accountability. Emphasis on management to lead by example and employees following to management direction [22]. This framework has elevated ownership to employees and management by creating an equal and consistent quality culture throughout the organization.

According to Crosby [20], quality management is a systematic way to ensure planned activities happen as planned. Total Quality Management may also be regarded as an organizing, planning and understanding every task, and this depends on all employees at every level of the organization [23].

Joseph M. Juran Research Study

Juran is one the most popular researchers on quality and TQM. Crosby and Juran refine the cost of quality as the primary and vital tool to measure quality. This theory is used to track the TQM process effectiveness, by selecting appropriate quality improvement projects and providing justification to those that do not believe in system [24]. Juran [16], defines quality as ‘fit for use”, and has further developed 14 steps that may lead to organizations to see results on improved management system. Juran’s ten steps to quality improvement to meeting customer satisfaction are as follows: [25] [19], see Figure 4.

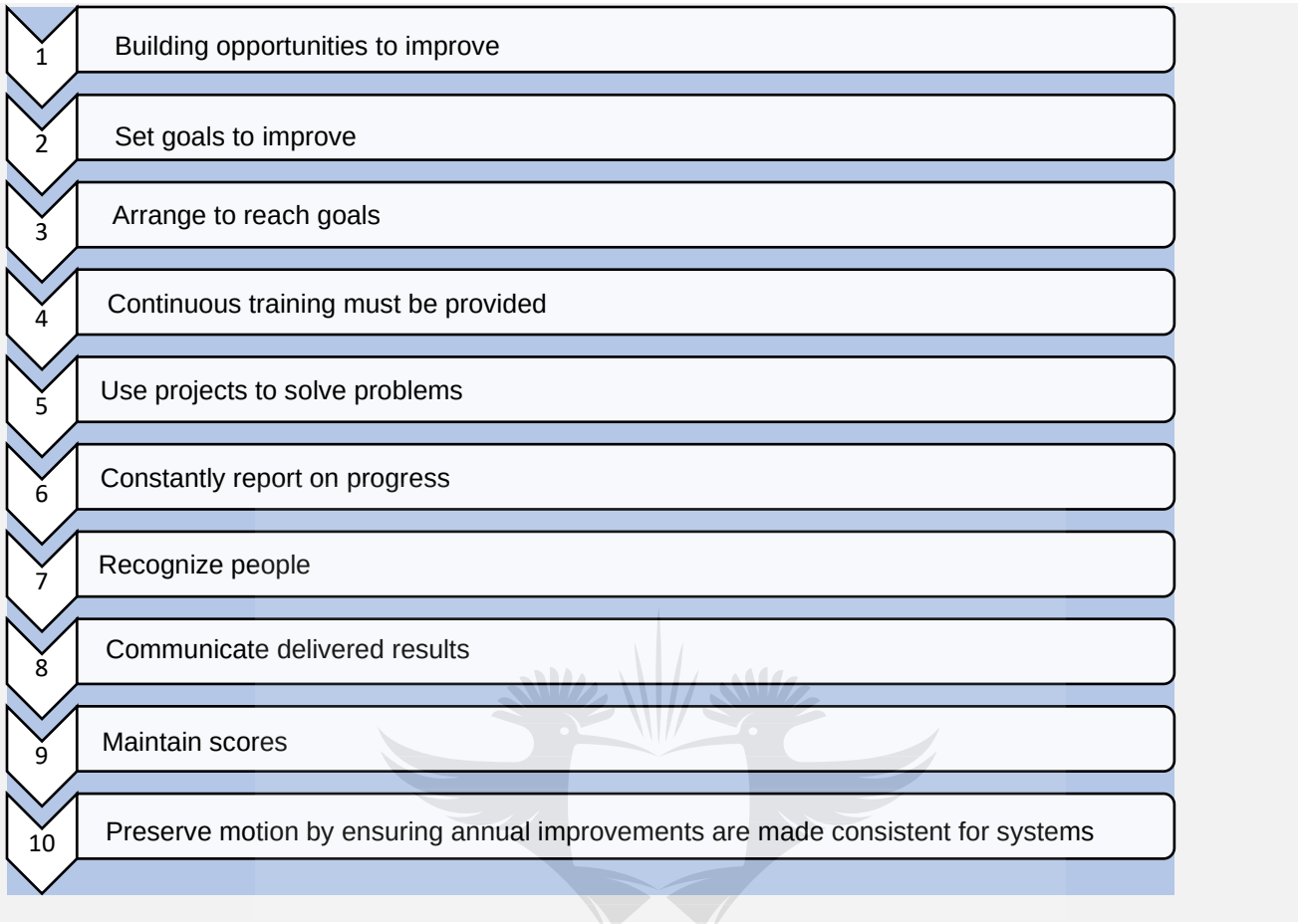


Figure 4: Juran Ten Steps of Quality Improvement

Source: Principles of Total Quality, *[25]*

2.2.2 Definition of Total Quality Management

Total Quality Management (TQM) is a methodology that focuses on continuous improvement, customer satisfaction and employee involvement [26], it is also presently used to improve product and service quality [27]. Total Quality Management may also be defined as the procedures and methods seeking to minimize the effect of a product, service or a process in order to increase quality and effectiveness [14]. The prevalent practices of quality management have over the years led to the expansion of TQM theory.

"TQM is an integrated management philosophy that aims to continuously improve the quality of products and process to attain improved customer satisfaction" [28]

Total Quality Management is also defined as a technique or model that raises flexibility, efficiency and competitiveness to organizations [29]. This definition lays emphasis on critical factors that are key to the success of implementing TQM. Dean and Bowen [30], defines Total Quality Management as a management approach characterized by different elements namely; principles, practices and techniques which are commonly applied in customer focus, team engagement and continuous improvement. The key-points of a programme is to improve the strategical planning of quality, in discretion to implement Total Quality Management principle [31].

The aim of Total Quality Management is to provide satisfaction to organizational objectives by introducing a management style that is quality centered which focuses on; customers, fact-based data, team orientated and seminar-led [32]. Deming management model contrasts with other gurus on what TQM aims to achieve, the Deming management model states that it does not keep track of customer satisfaction but aims in emerging leadership and organizational culture to directly impact the quality provided to customers [33]. Total Quality Management is the approach that significantly manages operations improvement as well as potential of improving business climate, enhancing business processes and culture and assisting for prospects in innovation and development [34].

Customer demand and need for improved market competitiveness has increased over the years. The involvement of technology and increase market sphere where everything is of good better quality, increased innovation, and better price rate has impacted the way TQM is perceived. According to Jonah, Ornguga and Torsen [35], this explains the reasons organizations need to advance and change to highest level of competitiveness, quality demand has increased from customers, market place as increased to be more competitive better than the main competitors; demand for more profits, improve in product and service innovation and improved product liability and reliability.

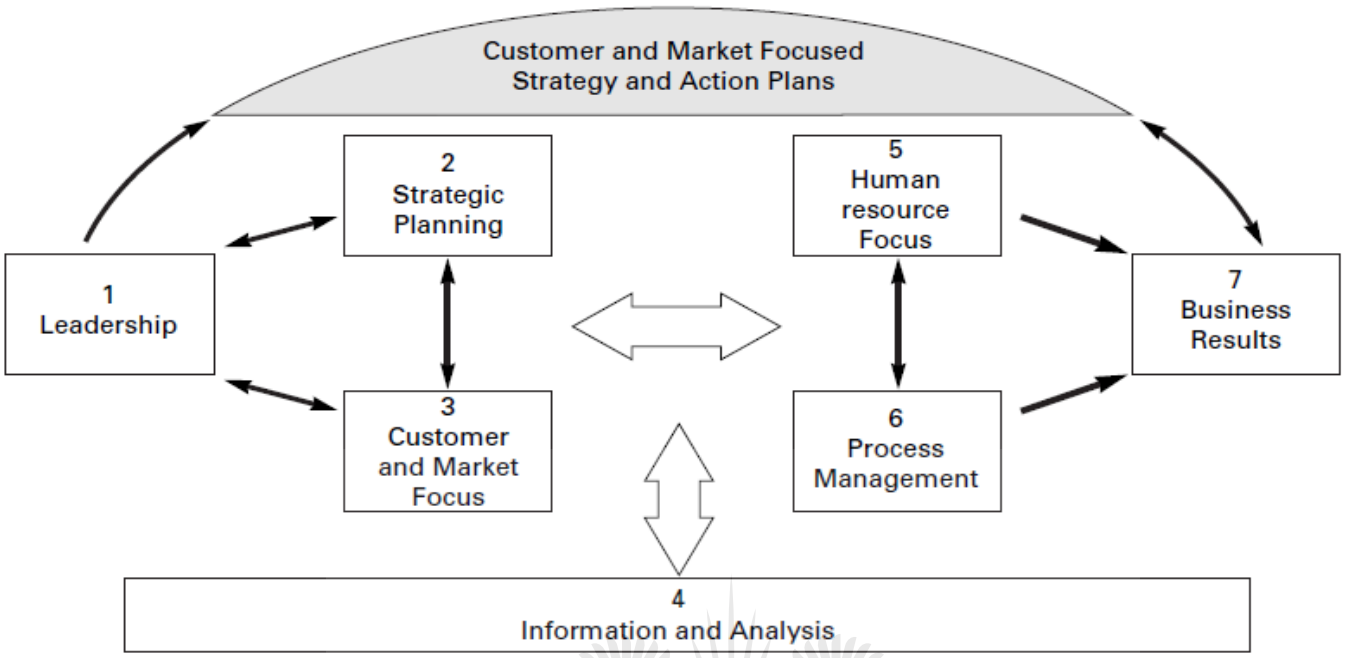


Figure 5 : Main TQM Framework

Source: Malcolm Baldridge Criteria

Total Quality Management is prescribed as an integrated approach, which constitutes of principles and practices, where the mandate is to improve the quality of organizational goods and services through constantly meeting and exceeding customer expectations in modest ways [36] .The diagram in Figure 5, constitutes on the main TQM frameworks from the Malcolm Baldridge Criteria. This framework shows the integration of all the seven TQM frameworks. See Table 2, where authors show common characteristics that describe the values of Total Quality Management in the context of various researchers. It is evident that the Total Quality Management characteristics differ from company to company based in the organizational context.

Total Quality Management may be covered by various definitions given by notable scholars in the area, not overlooking that there is a common definition that unifies all the perspectives, namely continuous improvement. It is upon organizations to take responsibility to maintain competitive advantage in the market to focus on improvement of the organization.

Precisely, TQM may be defined as a systematic approach used to manage quality with an aim to achieve higher performance in organizations, requiring commitment from management by adopting operative core quality elements as; leadership commitment, strategic planning, continuous improvement, customer focus, process management, employee involvement, human resources, the develop a better business management flow, which enhance better value stream mapping for the organization.

Researcher	TQM Dimensions
Suzuki, Tashiro [37]	1. Top management commitment, 2&4. Strategic planning Information and analysis, 3. Customer focus, 5. Human resources management, 6. Process management
Ushikubo, Tashiro [38]	1. Leadership and top management commitment, 2. Strategic planning, 3. Customer focus, 4. Information and analysis, 5. Human resources management , 6. Process management
Prajago, Sahol [39]	1. Leadership, 2. Strategic planning, 3. Customer focus, 4. Information and analysis, 5. People management, 6. Process management
Punnakitikashem, Laosirihongthong [40]	1. Leadership, 2. Strategy and planning, 3. Customer focus, 4. Information and analysis, 5. People management, 6. Process management Other: Supplier relationship
Prybutok,Zhang [41]	1. Leadership, 2. Strategy planning, 3. Customer and market focus, 4. Information and analysis, 5. Human resource focus, 6. Process management, 7. Business results

Table 2: TQM Frameworks from researchers' perspective

Source: Author`s compilation

2.2.3 TQM Business Processes

Total Quality management is a method to enable management to embrace social and technical dimensions intended at attaining exceptional results, that may need to be carried through using one of the frameworks [42]. The main purpose of TQM is to involve management and control of quality within an organization [43]. In order to understand the information and resources using the business process on interval value chain, mapping out the actual business process is the fundamental step [18].

Business process may be defined as specific tasks in a chain event performed as structured business outcome, see Table 3. Business process may also be defined as the work activities designed to produce known end result by applying logical organization of people, materials, energy, equipment and procedures [44].

Opportunities for collective engagement require to explore business proceedings and data requirement is the main driver for organizational transformation to project success according to business and Information Technology [45]. The ERP (Enterprise Resource Planning) system implementation brought an initiative that generates business process data required as output of requirement [46].

One vital concept of business process re-engineering is the ability to redesign business processes and technology improvement. Manufacturing industries in Indonesia use Total Quality Management application to ensure successful implementations of redesigning business process. These type of improvements shows successful results to product quality and organizations productivity [47]. To measure the success of organization, there are four elements which determine the if the goal has been archived. Time, cost, and quality [48] [6] and quantity serve as the main key indicators to measure [6].

Business Process: Input and Output

	Inputs	Business Process	Outputs
CUSTOMER	Customer Requirement	Place	• Sales order
FINANCE	Purchase order	Receive Order	
PRODUCTION	• Customer Requirements • PDCA (Plan Do Check Act) • Training and education • Objectives and Strategy • Process improvement • Quality improvement • Employee involvement • Traceability and identification	Order Entered on Production Schedule Incoming inspection Manufacture Final Inspection	• Communication • Training records • Inspection reports • Production output • Order tracking • Configuration • Concession • NCR (Non-Conformance Report) • CAR (corrective Action Report) • Final inspection • Release documents • Certificate of conformance • Drawings • Work instructions • Customer complaints • Conformity rate
SUPPLY CHAIN	Delivery	Ship and invoice	• Invoice • Packaging receipt

Table 3: Business process inputs and outputs

Source: Author`s compilation

2.3 TQM Functions for this study

2.3.1 Management Commitment and Leadership

Commitment from top management remains necessary and vital. The foundation or base of implementing TQM is top management commitment [49]. When the foundation is set and strong, the rest of the elements that support the model follow. Top management commitment is the main drive that significantly has a major impact on the quality performance of any manufacturing plant.

According to Martínez-Lorente [50], the main determinates of ensuring successful Total Quality Management implementation is top management commitment. They also stated that top management has to be the primary dimension in the application and stimulating the overall Total Quality Management approach, by accepting the maximum responsibility as well as providing essential leadership to encourage employees and restore trust within the business [51]. Ahire and Ravichandran [52] support the other researchers by stating that top management commitment affects other TQM elements namely supplier engagement, customer relationship and employee engagement.

Organizations consider Total Quality Management as cultural practice of manufacturing as a core competency [37]. Head of organizations become committed in initiating company goals, cultural values and systems which pursuit leaders to improve in continuous improvement and performance [32]. Leadership is significant to any company success, where effective leaders make use of human capital to gain competitive access and effective strategic leadership is a result of development of organizations [53]. As a TQM mandate top management is portrayed as the driver successful implementation of quality management, creating principles, goals and systems ,reducing costs , reduced time losses that serves purpose to improve organizational performance and satisfy customer expectations [54] [55].

Teamwork creates a corporate culture in encouraging all staff and from office workforce to shop floor workforce [56]. Lack of top management commitment on setting quality and implementation goals, may have a negative impact on business success in term of time loss and revenue [34]. The focus remains directed at tangible results but the impact on negative results is depended on the intangibles

e.g. teamwork, management commitment. There are critical factors that mostly determine the success of any system to work successfully.

2.3.2 Customer focused

Customer satisfaction is the main factor for sustaining a long-term relation between organizations and it`s customers [57]. Organizations perceive customer satisfaction and focus on relationship with the customer as the most lucrative factor to succeed in any business. Customer satisfaction to date is defined as the customer`s total evaluation of performance [58], performance may be evaluated with regards to delivering a quality product, producing at the right price and also delivering on time. See Figure 6, lists elements of customer focus.

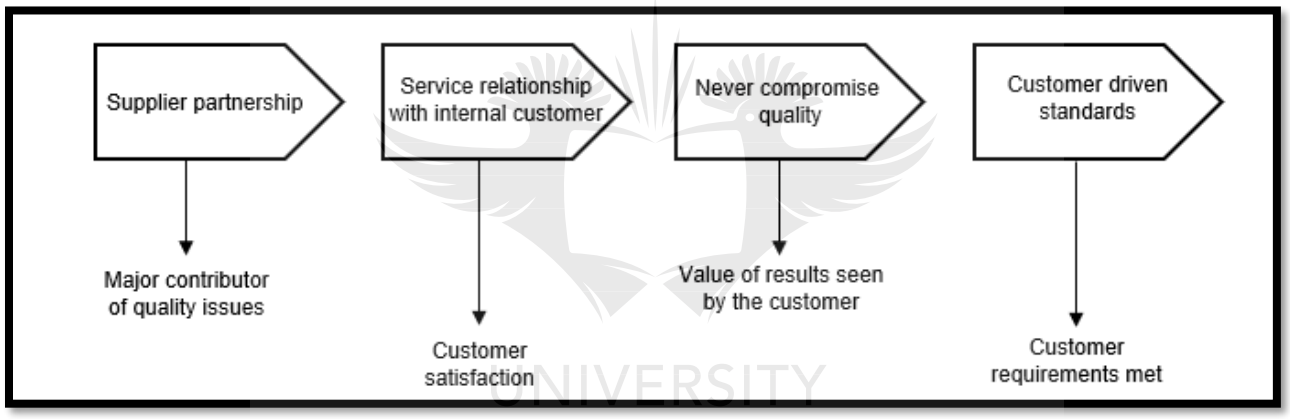


Figure 6: Customer Focus elements

Source: Author`s compilation

According to Nassar, Yahaya [27], it is management responsibility to intervene in finding cost-effective ways to ensure good quality of products and services as well as shortening response time to increasingly satisfy customer expectations. Improvement is aimed at measuring achievement of excellence, where excellence illustrates the success in a competition by gaining increased quality products and resulting to shorter lead time in term of efficiency offered to the customer [59]. TQM is seen to improve the quality at all cost by integrating organizational effort to meeting the customer quality expectation as per customer requirement , this may also be directed as “customer-defines quality” [27].

The perception on customer service quality has been influenced by the loyalty learning towards organizations and viewing the eventual success on the organization dependence on customer satisfaction [60]. Organizations measure their level of success by viewing business against customer expectations and not theirs, this has influenced organizations see business through the customer`s eye to measure their capability and performance [35]. Business performance upgrade is as a result of customer satisfaction and relationship, which is a vital technique to TQM [61].

TQM process when effective may produce improvements in the product and service quality that may result in profitability in organizations and increased customer satisfaction [51] [62].Customer focus principles empowering organizations to continue searching for new customer needs and expectations. The purpose is to lead organizations to continuously improve in development and introduction of new market products or services while adapting to market needs and evolution [39].

According to Singh, Kumar [61], customer needs are always key and recognized by customer-oriented approaches which are constructed and validated for further advancement. Customer satisfaction is improved by customer loyalty and significant implementation of TQM which may elevate enterprise market share. TQM may also progress to interest new customer and increase customer demand [63].

Organizations are modernized in relation to customer requirements, reducing operational cost, and minimized time and cost of newly product expansion by implementing innovative activities in quality management methods [64]. Malhan and Kundu [60], stated that the delivering services with advanced level of purposeful and technical quality, right price scale, at the same time allowing organizations to realize targeted rapid as well as long term profits, competitive advantage and growth. Frequent management reviews and period assessments are the main forums to address on how to maintain customer satisfaction [65].

2.3.3 Employment involvement

Engaging employees in organizational improvement initiation is one of the key TQM objectives, developing confidence and motivating employees to take part full participation in the process [64]. Employees want to feel important in any organization, employee involvements assure confidence and job satisfaction levels increases. One important aspect of ensuring employee commitment is through effective communication, employee motivation, training and development [33]. See Figure 7 for more details.

To gain a competitive advantage organization need to continuously train and motivate employees [11]. Employees competencies and capabilities require to be enhanced by means of training programs and advanced opportunities [66]. Deming have developed the TQM theory that rely on human factor, that which begins from the belief that majority if not all people are educatable, as a result, they are aiming out much effort and they need to be respected [48].

Workforce management elaborates on the recognition of employee performance on quality by putting emphasis on encouraging teamwork, providing training, involving employees in quality decisions [35], and motivating employees to voice suggestions. TQM requires full participation on member of the organization (senior managers, middle managers and employees) to ensure success. Seeking for opportunity in productivity of every process, product and service of organizations, and ensuring continuous improvement on all processes [55].

According to Gul, Duffy [66], where employees do not engage to continuous quality improvement initiatives, it is doubtful that other core TQM techniques may be successful. Barros, Sampaino [67], stated otherwise, that Quality Management Processes as employee commitment have a shared vision and customer focus, mainly contributing to the quality result and factors as ; “bench marking, team players , innovative manufacturing skills and closer supplier relationships”, may not directly influence quality output.

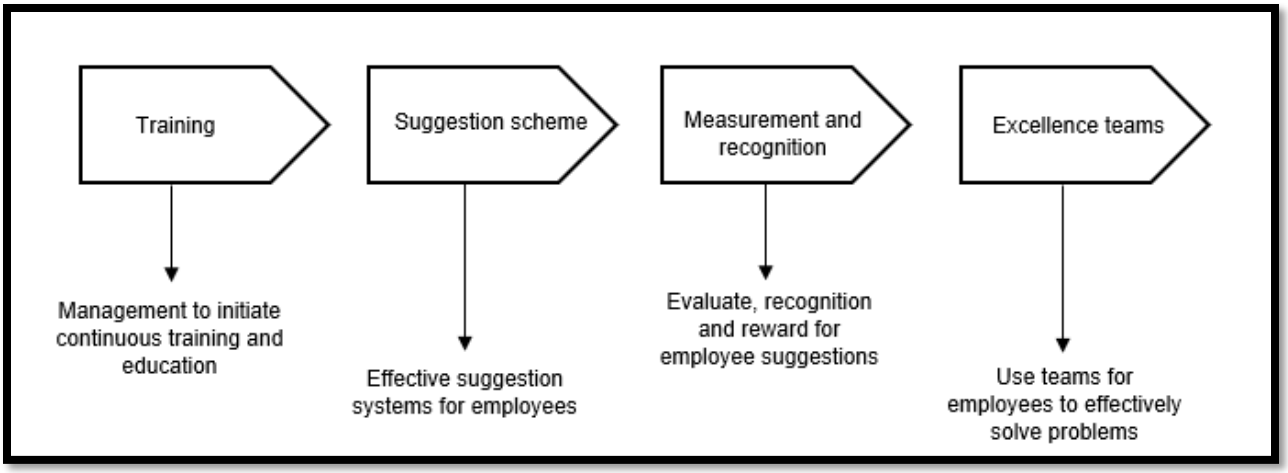


Figure 7: Employee Involvement elements

Source: Author`s compilation

Organizational culture is characterized by a company`s values and norms, as culture governs the effectiveness of an organization `s operational performance. Hailu, Mengustu [68], stated that production systems in Toyota portrays a manufacturing culture of continuous improvement through full participation of all employees , this results is based on the set-up of standards aimed at disregarding waste. Portrays good housekeeping to be a factor that may have a negative impact on an organization, where either is no 5S (sort, set in order, shine, standardize and sustain) commitment may result to 5D delays: “defects, dissatisfied customers, declining profits, and demoralized employees” [68].

Employees increased level of interest on the knowledge of customers, market competitors after going through a continuous improvement training, this has resulted in employees suggesting and submitting new ideas form product innovation [49]. Training is one of the vital aspects to ensure employee participation and as a result, the organization benefits from with regards to employees understanding and compliant to their process ownership, boundaries, and steps, less reliance on inspection, use of statistical process control, selective automation, fool-proof process design, Preventive maintenance, employee self-inspection [47]. Koilakuntla, Patyal [16], indicated that management need to train employees and get them involved to successfully implement Total Quality Management in business cycles for all processes.

Total Quality Management is also used in maintenance department , to set the goal of the any TPM (Total Productive Maintenance) which is similar to TQM, the program is used to improve productivity and quality also increasing employee morale and job satisfaction [69].

2.3.4 Information and Analysis

Information and analysis aim to serve the purpose of implementing TQM and continuous improvement processes by means of collecting information from customers. Ensuring that the information is analyzed for the intention to refine customer service and reaching customer satisfaction [70]. See elements on Figure 8.

Leaders in organizations use information and analysis to initiate decision making and used as an input to drive improved business outcomes [41]. In order analyze or determine business output, management needs to ensure that data is collected to make validated decision. Quality management generates excessive data, which is crucial to regulate the type of data that is important and is easy access to anyone [43].

By using information and analysis to gather the following data; cost reviews, inspection and testing, scrap and rework, providing the analyzed data with cost justification, may encourage management to support quality improvement projects, through effective TQM processes [47]. Organizations are responsible for enforce the availability high quality, reliability, adequate, and timely data and information for every employee or user in improving performance [48]

Process control is an entrenched principle of statistical process control which frequently applied to production processes. TQM is related to process control, where TQM also focus on upstream processes [39]. Process monitoring of quality products serves as a control method in preventing deterioration of key performances which are beyond human control, and this may also improve the optimization of performance and preventing failures [9].

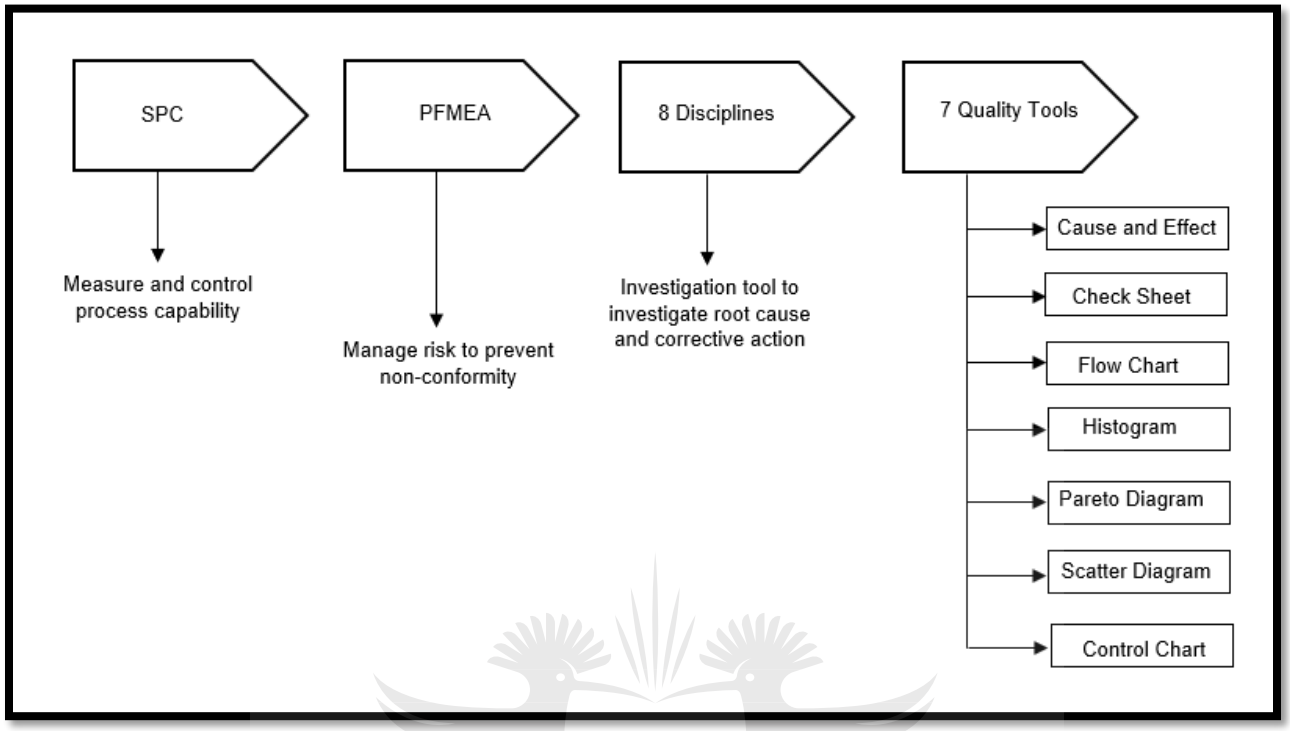


Figure 8: Information and Analysis elements

Source: Author`s compilation

2.4 TQM perception in various Departments

Organizations have in the recent years changed to using data warehousing as the main source of their database and develop various analytical applications as finance analysis systems, customer relationship management systems, and as well as decision making support systems [12]. These systems are initiated to make life easy for the person using the system as well as people use the system to gather data.

Storing data in different locations always has an impact for those who need to use the data when the need to use it, rather than having one central database to capture data which anyone can access at any time. The below Figure 9 shows how different business processes can integrate and become one source, where information can be pushed in and pulled out. Organizations are fighting to break the silos but there are still barriers that need to be explored according to process needs.

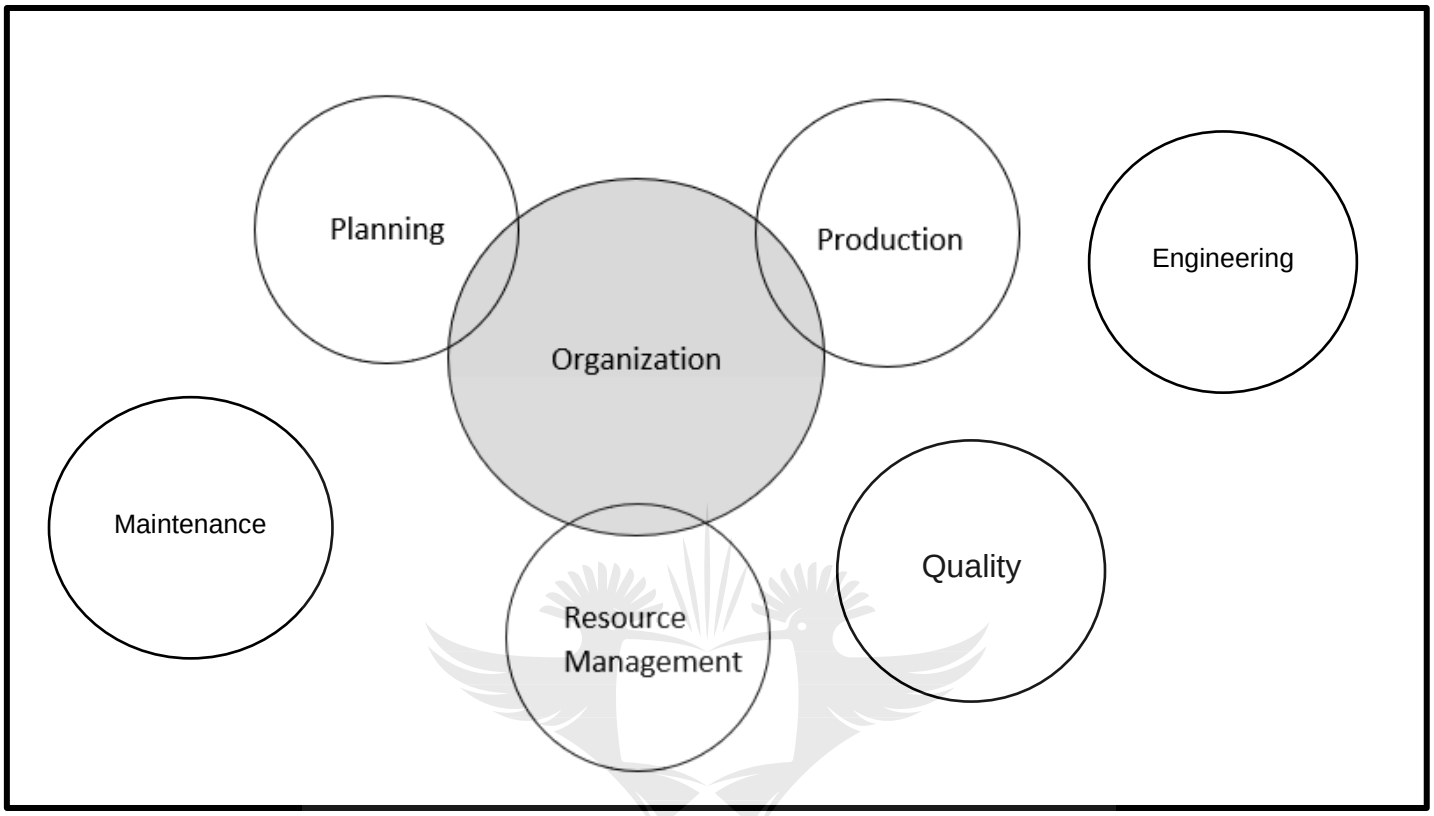


Figure 9: TQM perspective in various departments

Source: Author`s compilation

2.4.1 Maintenance

TPM activities are mainly focused on the elimination of six losses which a major; “equipment failure, set-up and adjustment time, idling and minor stoppages, reduced speed, defects in process and reduced yield” [71]. Total Quality Management in the maintenance department, serves as an advanced methodological tool which integrates various functions with production under the management commitment TQM element [72]. There are two closely related functions in a manufacturing system of any organization, quality and maintenance.

Total Productive Maintenance (TPM) and Total Quality Management (TQM) are two concepts that have over time emerged to realize a unique strategy in aim to improve and achieve world class manufacturing systems [69]. According to Mwanza and Mbohwa [71], the main objective of TPM is to advance the availability and preventing degradation of equipment achieving its maximized usefulness and the set objectives need solid management backing also motivating teams to engage in continuous improvement activities.

2.4.2 Quality

Quality is one of the obvious departments where TQM has the major impact of a company, in the manufacturing organizations. Example of processes which may be affected by TQM:

- Conducting Incoming Inspection of material from suppliers,
- Enduring production conformance on the production line,
- Verify conformance of product prior to customer release,
- Conducting process and system audits,
- Initiating non-conformance reports for product not according to specification
- Ensuring compliance of suppliers
- Tracking all customer complaints and returns

According to Amar and Zain [73], management is failing to measure customer satisfaction and using feedback to improve on efficient training programs. The best way of emphasizing the how to improve quality culture using TQM is by following Juran`s developed Trilogy [18] compromising (Figure 10) Quality Planning, Quality Control and Quality Improvement, see the outline below:

Quality Planning

Quality planning is a process that guarantees accomplishing required level of quality based on the outcome of that which is planned and organized [74] .Understanding customer requirements facilitates to navigate correct planning of activities that need to take place, the resources needed to

complete the task as well as proper time schedule. Successful planning results into a met objective which also supports in eliminating cost of poor quality.

Quality Control

Quality control mainly focuses on the fulfillment of quality requirements, while quality assurance focuses on offering assurance on the fulfillment of quality requirements [75]. Quality control aims to assessing the actual performance comparative to the targeted objective also ensuring that where there is variance it is acted upon to achieve full compliance.

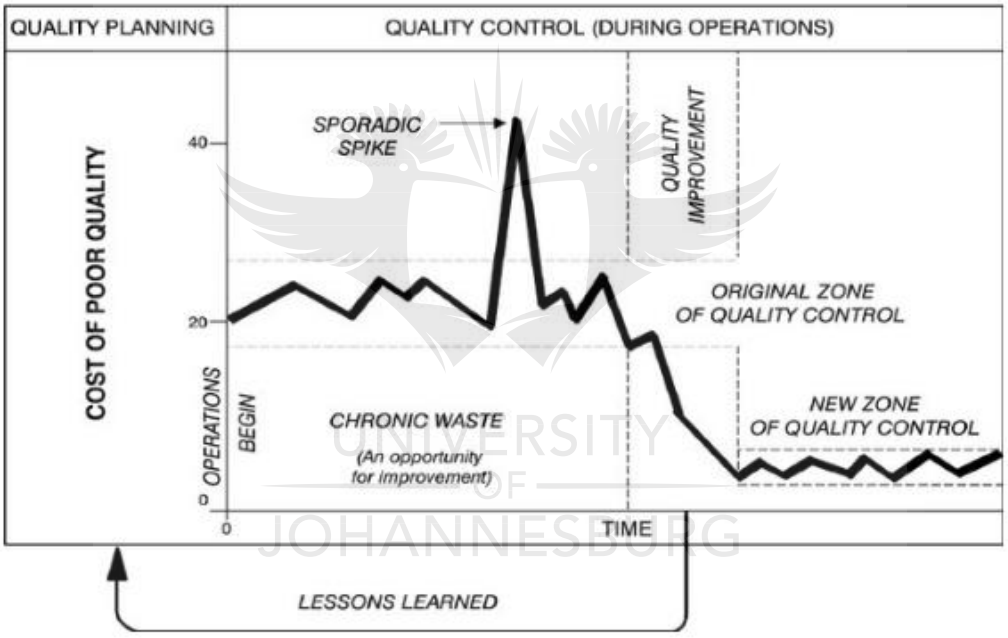


Figure 10: The Juran Trilogy

Source: Juran 1986

Quality Involvement

Quality involvement purposes on involving employees on eliminating waste and finding better ways to optimize processes and standardizing work procedures. The intended propose is to improve on the planning stage to ensure success on mitigating risk

2.4.3 Supply Chain

The aim of SCM (Supply Chain Management) is to ensure that products and services meet the specified requirements in a timely manner and reproducibly. More literature researchers perceive SCM practices widely as an effort to increasing organizational performance [76]. Table 4 below, details the Supply Chain Management practices as well SCM and TQM three dimensions which are developing and implementing strategies for SCM.

The five Supply Chain Management practices [34]	SCM and TQM three dimensions **[77]**
• developing customer-supplier relationship; • employing information and communication technologies; • re-engineering material flows; • changing corporate culture; and • identifying performance measures.	• strategic planning, • process management, and • analysis information.

Table 4: SCM Practices and SCM/TQM dimensions

Source: Author`s compilation

2.4.4 Production/manufacturing

In a manufacturing process the Quality Department make use of TQM element known as process management to improve the quality of a product in the production line. Managing different processes to reduce scrap and rework cost. While manufacturing uses TQM to manage and track productivity and delivery lead-time of finished products to customers [78].

Production/manufacturing work with different applications for process design, work time analysis, line balancing and factory planning. It is therefore extremely important to provide them with a centralized,

consistent data management system, see Figure 11. the figure illustrates the gain an advantage to how different business process input and outputs are dependent of each other.

Planning	Resource Planning	Operations

• Scheduling
• Engineering
• Finance
	• Maintenance
	• Human Resources
	• Purchasing
	• Material
	  ○ Receiving
	  ○ Stores
	  ○ Routing
	  ○ Warehousing
	  ○ Shipping
		• Production/ Manufacturing
		• Quality

Figure 11: Business Processes dependence

Source: Author`s compilation

2.5 Risks of implementing TQM

There are various factors that may limit the implementation of TQM, initiatives that normally contribute to the risk of successful implementation of TQM namely; leadership, product quality, continuous improvement, quality measures presented on critical success factors and vital focus to customer satisfaction [79]. Beshah and Berhan, [80] state that the main TQM critical success factors for implementing TQM are leadership (management), policy and strategy, and customer focus and satisfaction. While according to Mohanty and Lakhe [81],the two researchers perceive the limitations of implementing TQM as;

- Employees not working together as a team and lack of employee participation
- Lack of motivation for acting on planned strategy,
- Lack of responsibility and accountability from both management and employees,
- Lack of problem-solving management and co-ordination, and
- Lack of suitable procedures and information systems to help navigate to processes.

Chapter 3: Methodology

3.1 Introduction

The research uses mixed methods. This section defines the context of case study research, also defining the case study methodology, examining the significance of case study methods and describing the case study research design. The research presents a case study on a South African company which manufactures traction motors. Focusing on Total Quality Management business processes of various business functions which are inter-dependent and not integrated.

Qualitative research produces vast sums of literal data in the form of transcriptions and observations. Qualitative research may also be recognized as an analytical process which starts during data collection, with information that has been gathered which has also been analyzed and shaping the continuation of the data being collected [82].

Qualitative approaches may be associated with interpretative stance, while quantitative research methods may normally be considered as underpinned by positive mindset [83]. In the early 1990's, Strauss and Corbin [84] defined qualitative research as "any kind of research that produces findings not arrived at by means of statistical procedures or other means of quantification". Qualitative research may also be viewed as a methodology used to obtain specific information that may be based on other people's values, behaviors and opinions.

3.2 Research design

The main role of research design it to link the research questions to the data. Design is located between the two research methods, projecting ways of how the posed research questions is to be linked to the data and procedures to be used in answering the research questions. Research design combines data collected or the data analysis methods from both qualitative and quantitative research techniques to examine and build theories [85]. In this section, the research strategies and research samples are explained. Tools and procedures used to conduct this research in terms of data collection, direct observations (time studies) and case study.

This research adopts the DMAIC (Define, Measure, Analyze, Improve and Control) methodology. Researcher A: Bagare, Shekar and Ram [86], successfully applied the DMAIC methodology in a case study; to collect and analyze data. Applying the DMAIC process for this study, intended to improve on allocation of activities, work sequence in workstations and increasing production output in the Drive head Assembly Line. Identifying supporting attributes for each phase of the DMAIC process resulted in constructive results.

Researcher B: Krupakar and Kumar [87], successfully used time studies to collect data on sequencing steps and in order to improve on the cycle time. The purpose of performing time studies resulted in an optimized production output and reduction in labour cost. The context of this case study signifies the opportunity for improvement on processes and production efficiency.

The collection of the two researchers is adopted as the research methodology for this research paper. The DMAIC process is be used for this research based on the case study context involving sequencing steps, collection of data using time studies in various departments. This research adapted the DMAIC methodology process steps (Figure 12). The details are expanded below.

3.2.1 DMAIC Process

This research adapted the DMAIC methodology process steps, Figure 12. The details are expanded below.

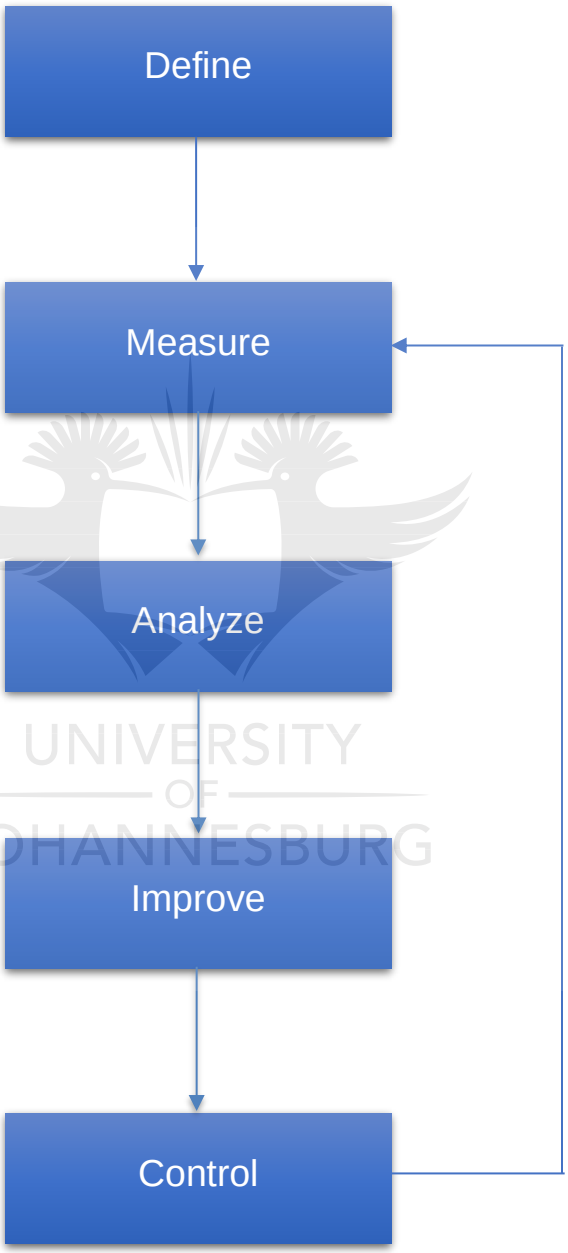


Figure 12:DMAIC Process

Source: Author`s compilation

Define phase

This phase defines the description of the problem relating to the presented case study.

Defining the problem at this phase is to achieve the following objectives:

- Begin the commence the process by defining the functional areas of the business
- Identify business processes that are affected
- Define all sequencing steps

Measure Phase

At this phase, 'Process capability analysis' is used in order to establish if the process is capable or not [88]. This phase is supported by data collection from the define phase. A time study method is used to collect the data.

The measure phase intends on meeting the following objectives:

- Measure time of each activity
- Measure process stability and performance

Analyze Phase

The cause of the problem is identified at this phase [86]. All contributing factors that cause the problem are recognized within each sequencing step.

- Analyze collected data
- Analyze root cause of problem
- Use tools to project standard vs. actual

Improve Phase

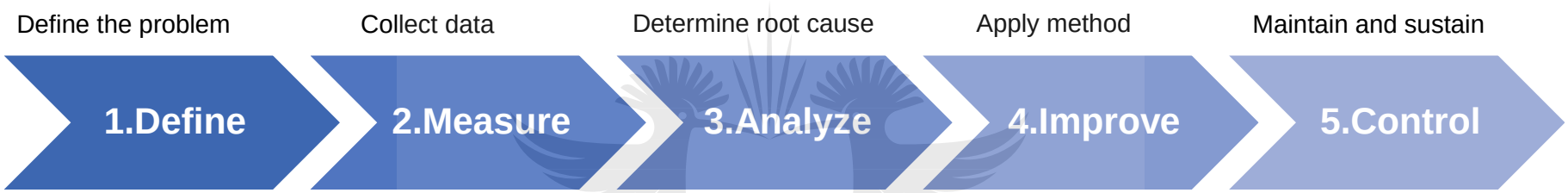
Process map as well as cause and effect diagram are used to identify the corrective actions that may lead to improvement [88]. Apply method to improve from the results captured from the measuring phase and verify the results.

- TQM Business processes integration
- Applying digital technology

Control Phase

Maintain and sustain implemented solution in improve phase. Provide necessary measures for solution to be sustain.

3.2.2 Case Study phase objective:



1. Define the following:
   - Functional areas
   - Affected processes
   - Sequencing steps
2. Conduct time studies to collect data
   - Data collection
   - Process capability
   - Resources used
3. Establish root cause of long process times
   - Non-value add activities
   - Optimization
4. Apply digital technology
   - Simulate improved process results
   - Use ERP system to integrate all business functions
5. Validate improvement
   - Purchase tablets
   - Train employees
   - Evaluate results

3.3 Research Framework

TQM is configured to the organization's business processes, although digital technology has not embedded into the process. The aim of the case study is to provide a practical example of using the model in real life practice. It should also be mentioned that only one firm selected to conduct this case study and this firm is not asked to practically apply digital technology, which is used to access the capability of digitalization processes.

ABC Manufacturing company is a traction motor manufacturing company. The real name of the company has been changed for confidentiality. ABC Manufacturing uses a manual system to collect data between departments and it takes a vast amount time to process between departments. The aim of this research is to minimize the time it takes to process information and optimize the interaction between departments by moving to a digital solution system.

Majority of organizations are moving in the direction of increasing processing speed, increase in capacity, increase in data accuracy and ability to access real time data. The design and implementation of TQM system is to encourage integration within business processes and ensuring improvement on process engagement amongst people. Management commitment `s main responsibility is to engage employees in passing knowledge on continuous improvement.

There is a reinforcing instrument that has been used to determine the data set of the organization. The strategy is to collect data from sub-categories (Figure 13) of processes in form of direct observations. The process initiation is developed from the main functional departments of the business, observing all the business inputs and outputs for each business process. Then focusing on the sub-business functions within the separate departments, starting with regular visits on the shop floor, then through direct observations of their processes and talking to quality inspectors, supervisors, and the stores supervisor. The value stream mapping instrument is used to give accurate measurement of process steps and using time study to quantify processing times. The time standard is average observed time is calculated by the (direct observed time x rating factor @100)/100 = Basic time to complete the full cycle.

A business functional approach is developed as a framework for data collection (MESA). This framework is adopted for data collection. Over a period of two months, daily presence on the shop

floor between departments, data gathered by the Author for the first two weeks on the departmental level and thereafter the data on the functional departments is collected by the responsible quality inspectors, production supervisors and stores supervisor. At the end of each day the Author consolidated and verified all collected data. The functional teams involved in gathering the data where trained on how to perform time studies and they are all assigned a stopwatch as well as a check sheet to record the time it takes to perform the activities relating to this case study.

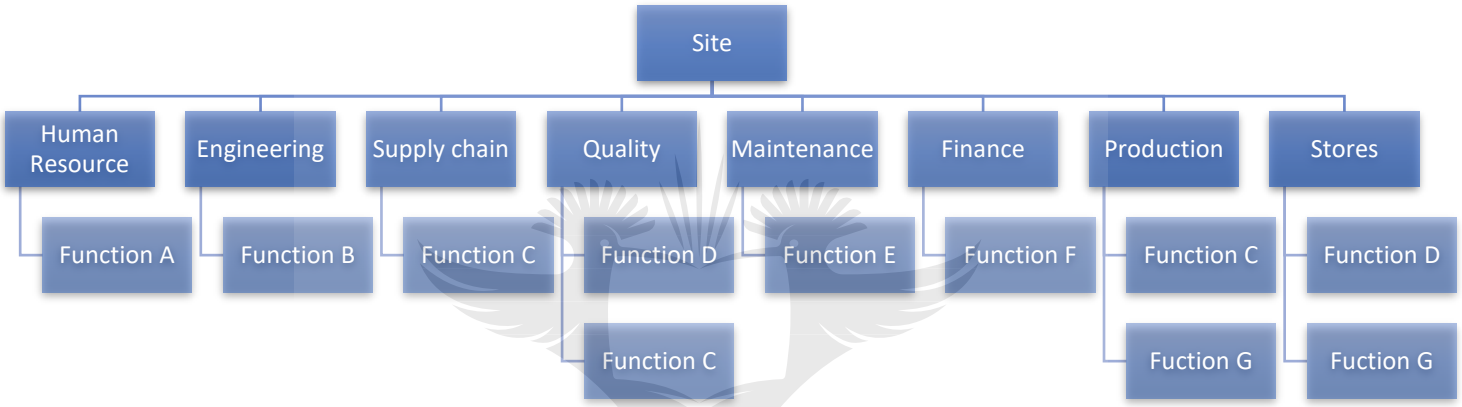


Figure 13: Site Functions Framework

Source: Data collection

Researchers search phenomena in qualitative study, relating to the thought process, which is a challenge extracting or educating using research methods which are conventional [89]. For the present study, data is collected, and observations captured for every activity. Precisely, the persistent comparative method [84] is used to analyze the collected data and determine manual workflow perception and the need to implementing digital technology.

3.4 Data collection

In order to carry out the case study, evidence is primarily from two sources: observations and time studies. A time study is measured time to conduct an activity from start to completion. According to Reddy, Rao and Rajalakshmi [90], “motion and time is defined as a systematic analysis method designed to establish the best way to execute the repetitive task and to evaluate the time spent by an average worker to fulfill a given task in a fixed workplace”. In this study only the observed time is used. All sources offer unique information which related to the subject matter, this approach reduces risk of using one source of information. Direct observations conducted and findings to be presented in Chapter 4.

Using the stopwatch to capture the processing time for each activity performed by the employees in the various workstations. Observation sample is x10 times per cycle, the mean of each cycle is used as the average observation result reflecting the actual activity processing time;

1. Using the stopwatch to capture the time when an activity starts and when the activity ends
2. Recording the start time and end time taken for the activity to take place
3. Complete daily check sheet and communicate results to author at the end of each day
4. Author captures total time per activity at the end of each day
5. Author calculates average processing time for each activity (repeatability test)
6. Author completes value stream map for each process
7. Author presents results in chapter 4

Reliability and validity

There are two ways that demonstrate and communicate the rigor or research processes and worthiness of research findings, the two ways namely reliability and validity. Where the research to be helpful, it needs to be constructive and straight forward to avoid misinterpretation. According to Campbell and Stanley [91], true experimental designs need to be endorsed, providing an advanced degree of control produces a maximized degree of validity based on experiments.

Through data collection the researcher data collected are kept safe to validate and to confirming that assumptions and conclusions which are made are related to the data that is collected reliability and that the data is valid.

Chapter 4: Results and Discussion

4.1 Define Phase

As per the methods chapter the starting point is the define phase, this phase describes the problem relating to the case study scenario of company ABC Manufacturing which is used to support the research.

4.1.1 An example of dependencies may be illustrated via detailed scenario

Stores Department receive parts from the supplier and stores sends parts and documentation to Quality Department for incoming inspection. After parts are inspected by the quality inspector and deemed conforming the parts are then released back to Stores Department by signing and stamping the receipt documents. Once Stores are in possession of the parts, production generate a pick list from the ERP-Epicor system prints it and sends it to stores as a request for material to be issued, the pick list has an assigned job number. Stores Department uses the same ERP-Epicor system to issue the parts to production.

Traveler: is a process control document where steps of an operation are recorded.

In the production department each operation has a process control document, the following is recorded on the document:

- The serial numbers of the parts they work with as the form part the of product configuration,
- “In process inspection” measured values,
- The actual time it takes to complete the observed process,
- NCR (Non-Conformance Report) number if there is any raised and,
- Sign-off by the operator once the operation is complete.

The complete traveler is then scanned onto the public drive, the reason the travelers are being scanned is due to historical loss of records. Once the traveler is scanned, the original documents are placed in a temporal repository in the Quality Department this happens after each operator completes an operation. Figure 14 shows number of workstations in production. Each process operation has a minimum of five operators.

The travelers are compiled once a product is fully completed and ready to be invoiced. The quality inspector completes the physical final inspection check sheet of the assembled traction motor and take pictures of the drive inspected. All records are saved on the public drive, including photos and inspection check sheets. The inspection also includes completing a configuration log where all related serial numbers are recorded as part of the customer requirement. This log is available on an excel document.

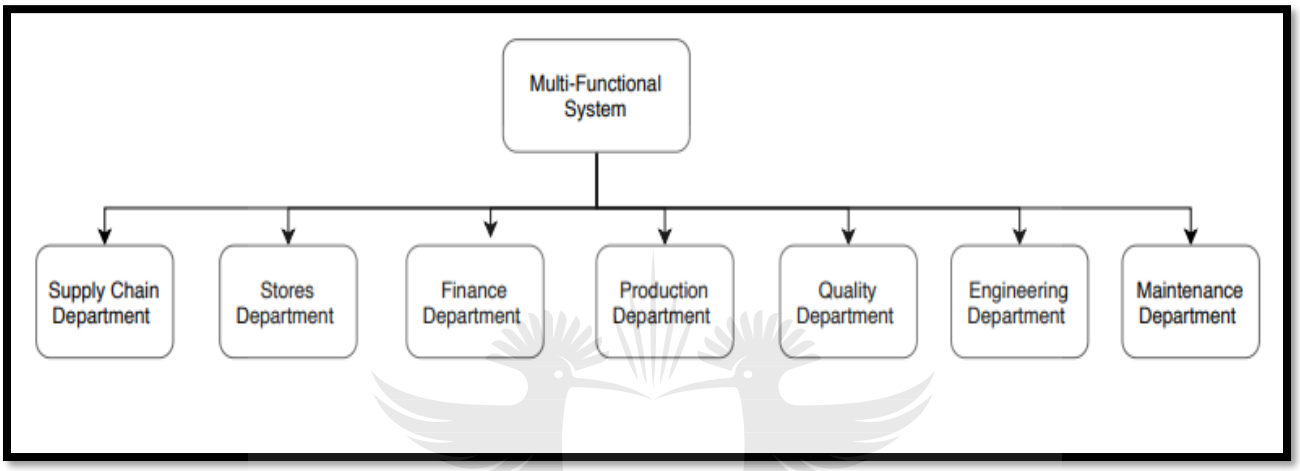


Figure 14:Functional Department

Source: Author`s compilation

Prior to invoicing, a traveler data pack is required for complete the traction motor unit. The quality inspector compiles the data pack constituting of ten traveler packs to make up the overall configuration kit for the complete traction motor unit that has been manufactured. The travelers are accessed from the temporary repository in the Quality Department and compiled together. Once the data pack has been complied a COC (certificate of conformance) is manually generated and emailed to Supply Chain department for invoicing to the customer.

4.1.2 The effect of business processes- the difficulty of standardizing and integrating

The integration of various business process systems within an organization has always been a challenge. Majority of organizations that face the problem of this magnitude strive to standardize and therefore use an approach where business processes are united to forming to one set standard. Financing and CAPEX (Capital expenditures) is the biggest challenge that organizations face when they are ready to implement new technologies and innovation.

According to Telukdarie, Buhulaiga , Bag, Gupta and Luo [92], integration and standardizing depend on the engineering efforts needed to designing, testing, integration and deploying such applications. Introducing a new way to capture information in a digital form and no longer in a manual format, configuring the business process systems into one central configuration system have a major impact on the finances of the organization. The new introduced solution requires a new digital tablet and configured ERP software.

Additional consideration in the justification of digital technology in TQM business processes solutions may include:

- Potential elimination of silos between departments with one central system
- Eliminating the need by different departments of having their systems of their choice
- Reducing time for operators to input information of their travelers
- Having access to firsthand raw data which enables good decision making
- Moving from a stigmatized mindset to get things done faster and not wait for other people
- The ability to eliminate mistake and safe proof the system
- Ability of fast-tracking invoicing process to team a less lead time

This research aims to provide the insights into various options of applying digital technology in TQM business processes in a manufacturing industry. The practical and technical requirements together with examples enablement are provided. The provided simulation offers then operational mindset of the solution.

4.1.3 Departments supporting Manufacturing process

The manufacturing process is supported by various departments with different responsibilities. All departments are depended on each other, this case study support the aim of the study in supporting TQM business processes to optimize their internal processes considering both inputs and outputs of their processes, see Figure 15 below. Refer to Appendix A for actual time studies results.

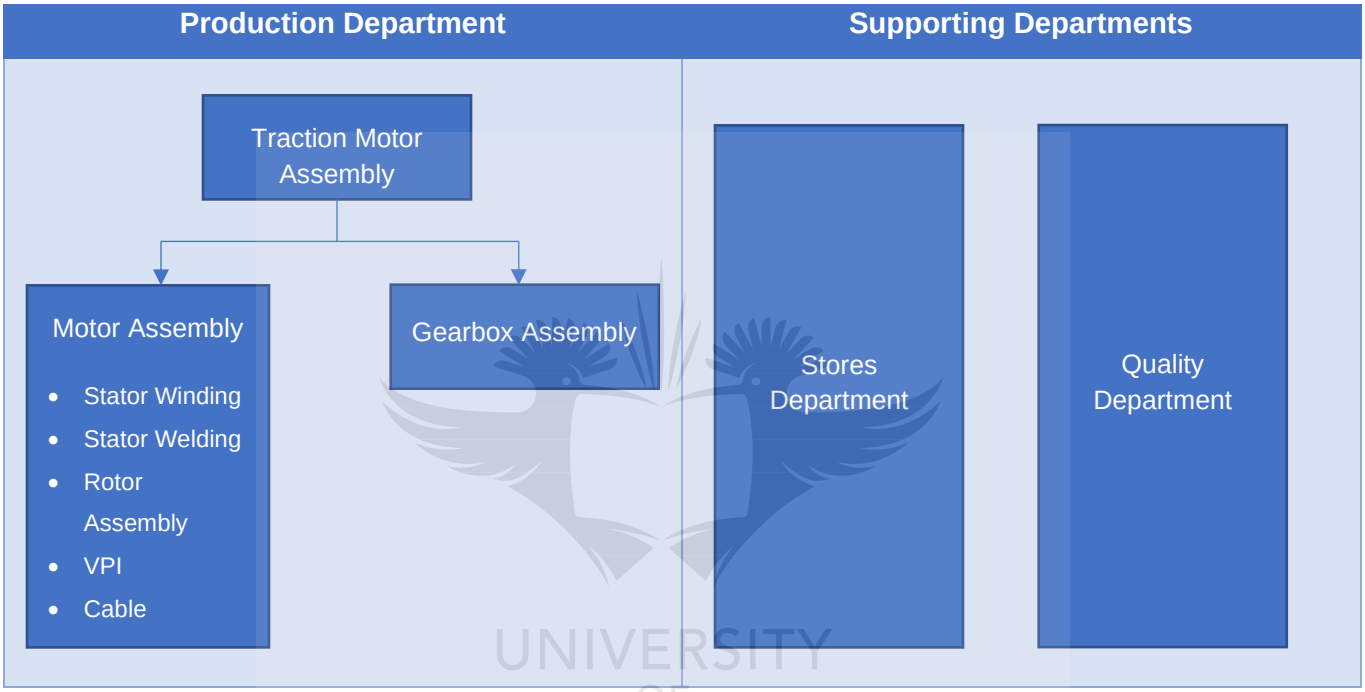


Figure 15: Production structure and supporting departments

Source: Author`s compilation

4.2 Measure Phase

The measure phase is the second phase to gather data relating to the data collected from the define phase. Time study method is used to collect data in this section. The total time to perform every activity in each department is measured.

(i) Stores Department

- Total processing time, Table 5 and process flow Figure 17
- Receives documentation
- Documentation hand delivered to Quality department
- Received paper copy of pick list from production and issue parts with pick list

Total time	35 min per part received
Receiving inspection documents from the supplier	10 min
Verify quantities of delivery and sign receipt	10 min
Deliver documents to quality department	10 min
Capture parts into ERP-Epicor system	5 min

Table 5: Original Processing time in Stores Department

Source: Data Collection

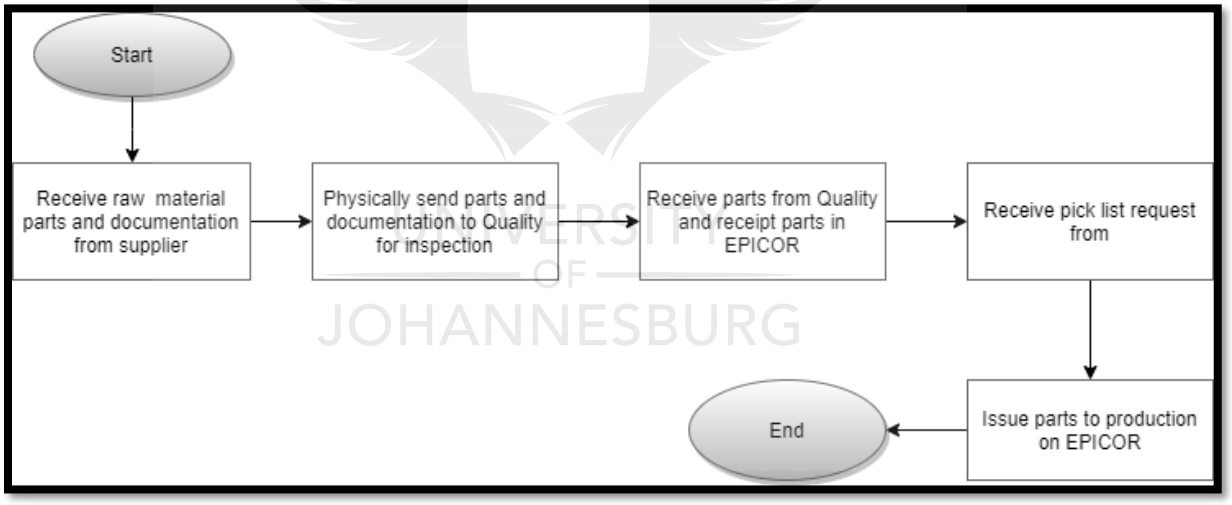


Figure 16: Function of Stores Department

Source: Author`s compilation

(ii) Quality Department

- Total processing time, Table 6, Table 7 and process flow Figure 18, Figure 19
- Print inspection check sheets and latest drawing to conduct inspection
- After competing inspection complete inspection check sheet by hand
- Scan completed check sheets
- Sign Stores documents
- Make copies of Stores documents
- Hand deliver documentation back to Stores department
- After competing inspection complete inspection check sheet by hand
- Complete the configuration log
- Compile the data pack (x10 travelers per pack)
- Complete the configuration log
- Compile the data pack for all processes
- Generate certificate of conformance and email to Supply Chain

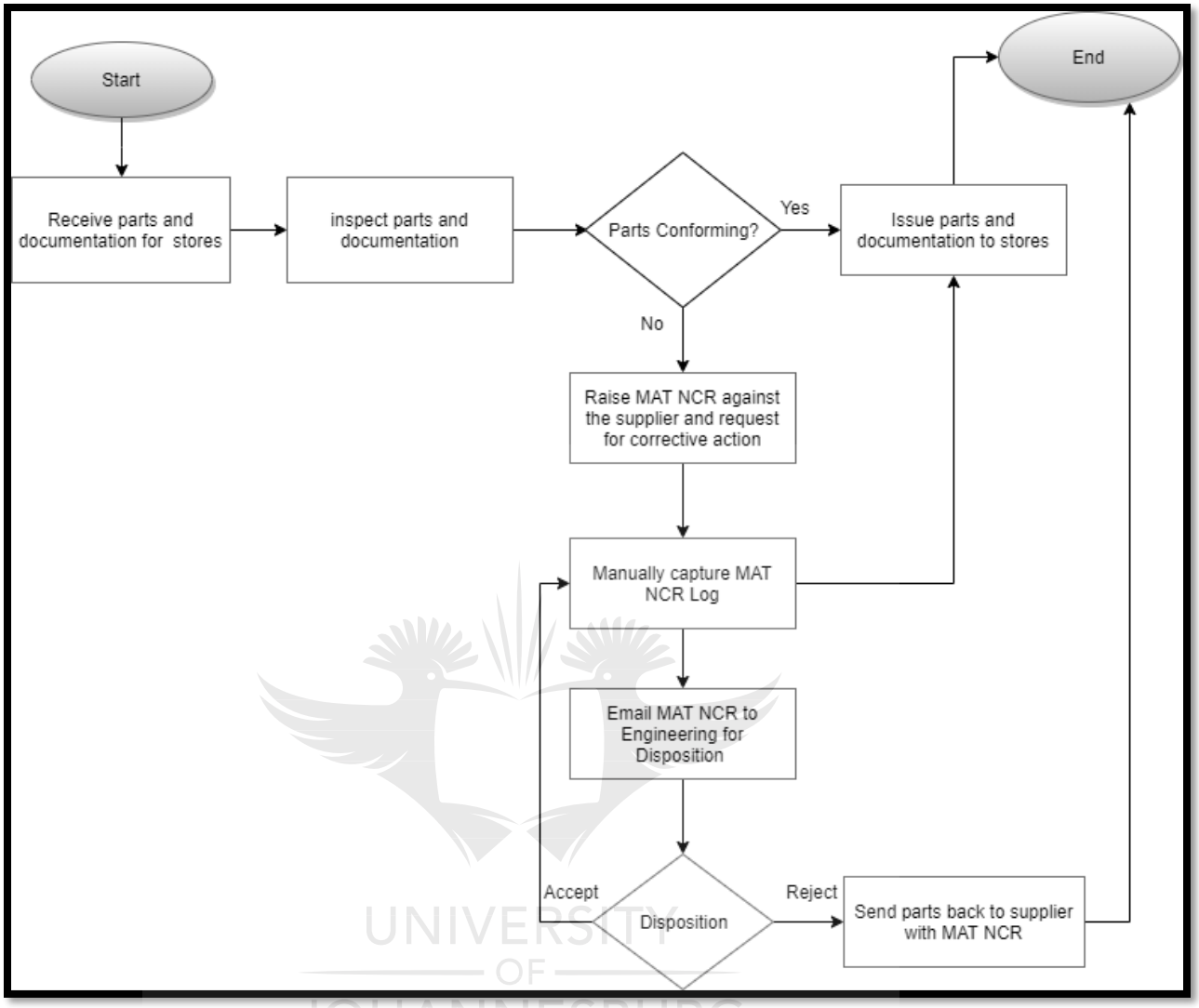


Figure 17:Quality Department incoming inspection Flow chart

Source: Author`s compilation

The total processing time for this activity may be optimized between stored and quality. The process between the two departments is documents manually transported by a person from stores and then later documents are transported back to the stores by quality inspector once the part has been inspected and released. This proves that a configured system supports TQM business processes even if when they are independent. The Quality Department in incoming inspection uses manual inspection sheets which cause the process to be time consuming, potential for error based on

manually logging and scanning the inspection check sheets into the system adds to the time availability of instant data. The total processing part which includes, the following in Table 6.

Total time	45 min per part received
Print inspection sheet	5 min
Complete the inspection check sheet (manually)	20 min
Hand deliver signed documents to Stores	10 min
Scan and save inspection sheets	10 min

Table 6: Original processing time Quality Department-incoming inspection

Source: Data Collection

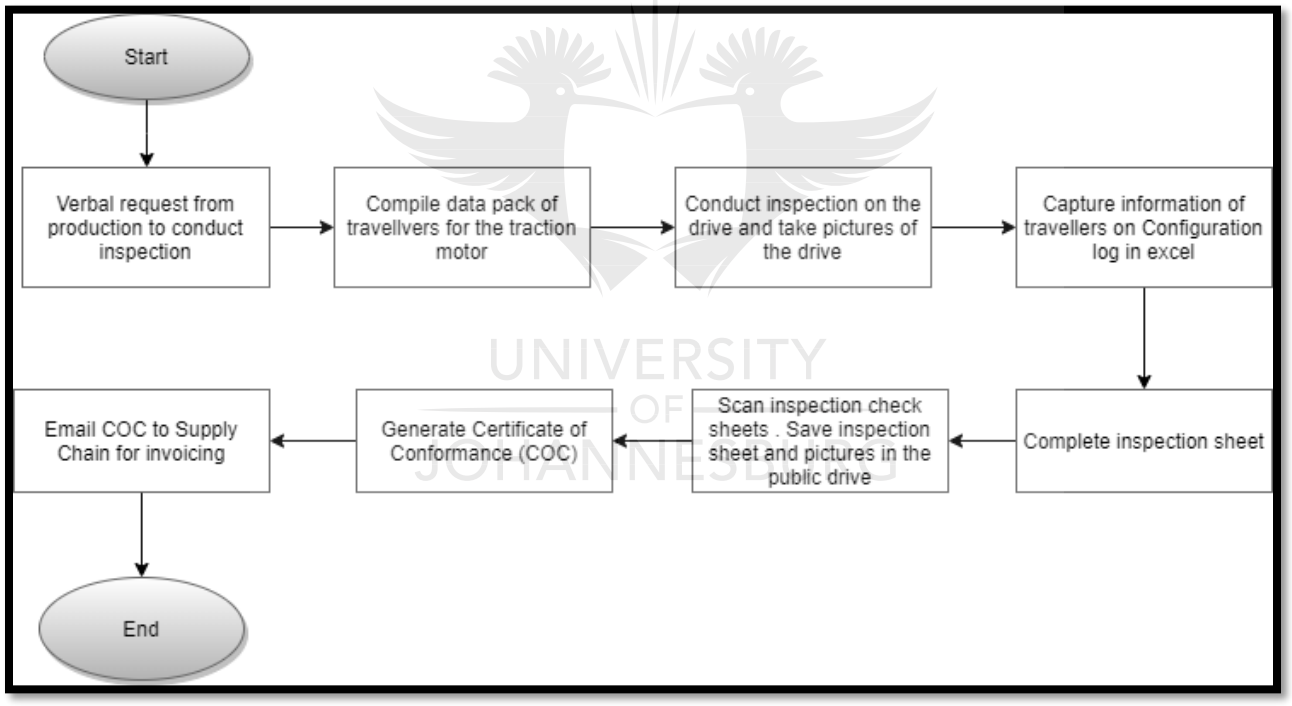


Figure 18: Quality Department Final Inspection Flow chart

Source: Author`s compilation

The total processing time for this activity may also be optimized between quality and production. The production personnel verbally notified quality once a traction motor unit requires inspection. The data pack compilation and populating the configuration log is the most challenging part for the quality department for the following reasons:

- Information missing on travelers
- Information missing on travelers
- Incorrect information and signatures on traveler
- Duplicated information captured, e.g. serial numbers
- Travelers not available at the time for invoicing

See breakdown of processing times on below Table 7.

Total time	90 min per traction motor unit
Print inspection sheet	5 min
Complete the inspection check sheet (manually)	15 min
Take pictures	20 min
Scan and save inspection sheets	10 min
Complete the configuration log	10 min
Compile traveler data packs	20 min
Generate COC and email Supply Chain	10 min

Table 7: Processing time Quality Final Inspection

Source: Data Collection

(iii) Production Department

- Production processing time, Table 8 and process flow chart Figure 20
- Create a new Job on MES_Epicor and print job card to request material from Store
- Complete traveler after for each operational stage
- Once completed with operation, scan traveler onto p-drive
- Walk to Quality department and place traveler in temporary repository

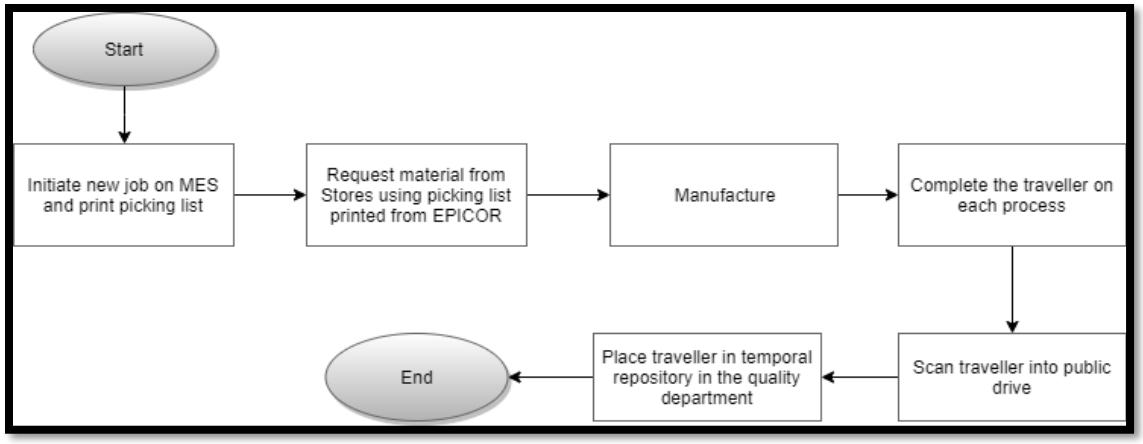


Figure 19: Production Department activities

Source: Author`s compilation

Total time	115 min per motor assembly traction motor unit
Print pick list to collect parts from stores	5 min
Hand deliver pick list to stores	15 min
Print new travelers and collect them from the printer	20 min
Complete the traveler after each process (manually)	15 min
Scan and save traveler	45 min
Hand deliver traveler in the temporal repository in Quality	15 min

Table 8: Processing time for Production

Source: Data Collection

(v) Supply Chain Department

- Processing time, Table 9 below
- Invoice customer based on information provided by Quality Department.

Total time	10 min per traction motor unit
Request COC from Quality	10 min

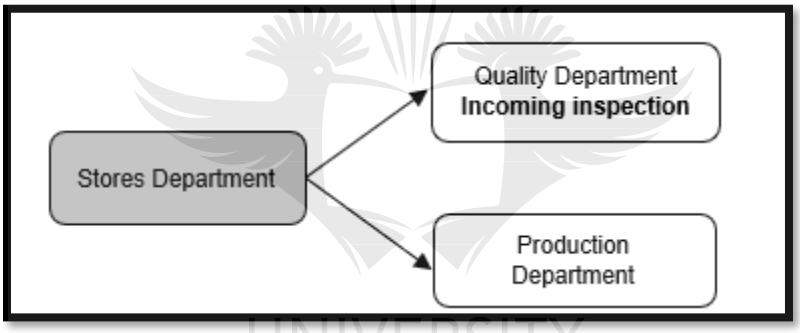
Table 9: Processing time for Supply Chain

Source: Data Collection

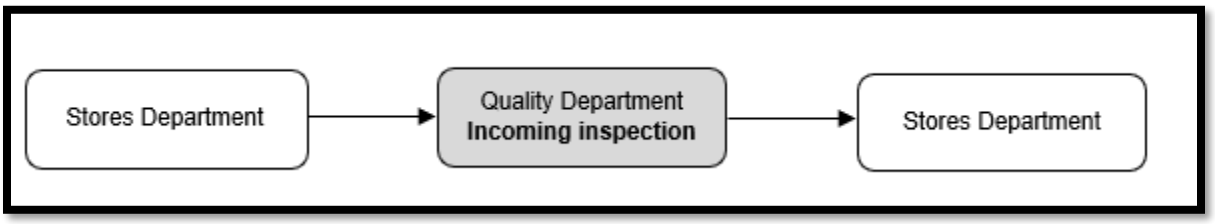
4.2.1 Process Capability

The ABC Manufacturing company is using manual process from receiving parts in the stores to invoicing the parts to the customer. It takes multiple time for multiple departments to share information, each business process takes an exceptional amount of time to process their own departmental activities. All departments are working in working in silos and not integrated regardless the fact that they all use the same information.

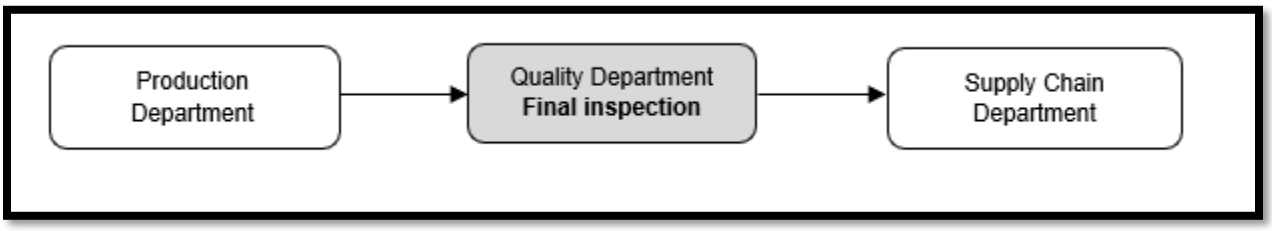
It is found that the store department is servicing two departments; quality and production but there is but there is no system that links the business processes. Documentation is exchanged physically between departments and not electronically. The processing time between receiving parts and receipting parts after inspection take a total of 35 min per part received.



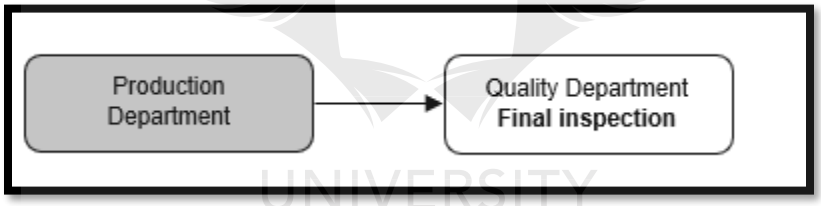
It is found that the quality department is providing its service to three departments but there is not streamed line workflow or system that may support all four departments into one centralized configuration system. The total time it takes to process information in the incoming inspection section with raising a Material Non-Conformance Report is 65 min and without raising an NCR is 45 min per part inspected.



While the final inspection processing time is 90 min per traction motor delivered. This time is non-value-add but the activities taking place are there to support the business process to reach their objectives.



It is found that the production department has different sub-divisions which support the overall manufacturing process. Each sub-division is unique conducting different operations, but the output of each process if the same, all processed need to complete a traveler and scan the traveler at the end of their process operation. Some operations are deepened of each other whereby the next operation needs to take over by completing the traveler document. The traveler size varies per process operation. The processing time in production is 110 min per traction motor unit drive.



4.3 Analyze Phase

The analyze phase is the third phase to identify the cause of the problem, the information is analyzed based on the data collected in the measure phase.

Time studies are conducted with a stopwatch to collect data, see Appendix B, on the overall processing times, the total processing time per department is as per Figure 21. The aim of collecting the data is to analyze possibility to optimize workflow of TQM business process by automating all the processes. Organizations are challenged to optimize processes, due to cost implications and the complexity of standardizing processes. Various TQM business processes support one another using different systems, which may include manual systems to process information and data. The challenging factor at company ABC Manufacturing is for each traction motor produced, too much time

spent on processing information and data, considering that information flow is a non-value add activity which the customer is not accountable for.

Department processing time	Original time (min)
Stores Dept.	35
Quality Dept. Incoming inspection	40
Production Dept.	115
Quality Dept. Final inspection	90
Supply Chain Dept.	10
Total time (min)	**290**

Figure 20:Original processing time per department

Source: Data Collection

Organizations are considerate on managing the flow of data and information in their businesses. The need for improving on systems and opportunities to optimize processes has been neglected for far too long. From the banking sector, insurance industries, manufacturing industries, schools and colleges; digitalization has become the norm and no longer an expensive exercise. The level of technology in all sectors has created a platform for organizations to be innovative and flexible at the same time.

The overall configuration system is the utmost best solution to making business process to speak the same message by accessing the same information from one single source. The manufacturing workflow has four departments which are using different method to process information and capture information which is potential duplicated.

4.4 Improve by applying Digital technology

The improvement phase is the fourth phase, in this phase digital technology is applied on the current system to simulate intended results.

Digital technology is a process of introducing the use of tools and technology to improve the way of doing things. Digital technology has the capacity and capability to transform customer focus goals into a real achievement, habitually creating the full potential to self-service. Digitalization has the ability to transform time wasting transactions and manual tasks that are part of a business process, particularly where there is more than one system is involved [93]. The impact results are more evident between a business process that is manual and one that is digitized.

According to Disney`s Milovich [94], most employees use social media platforms (Facebook, twitter, Instagram, WhatsApp), and interact with various companies using digital technology in their personal lives, nonetheless things at work are more difficult and complicated. The technology is equivalent, but people always treat it different as the mandate is not the same.

4.4.1 Benefits of Digital Technology

There is no reservation about the fact that most organizations are becoming more aware of digital technology and its capabilities to drive information faster and more effective. Information Technology has become the center of improvement in our daily living, with a benefit to revolutionize digital information. The importance of ensuring that people in organizations are digitally literate and have adequate access to digital equipment to ensure confidence and capability to use digital systems to their benefit [95]. In some cases, digital capabilities do enable continuous improvement based on routine associated to the following; information flow, integration of service task, and centralized monitoring of service processes [96].

Some of the benefits of digital technology is for managers to address difficulties before they become critical by using real time data reports and dashboards to make decisions [97]. Digital technology has more benefits to simplify processes and to bring better job satisfaction

Other benefits as [98]:

- Increasing work effectiveness and efficiency,
- Increasing employee morale
- Making tasks easier and simpler
- Increase work control of employees
- Reduce complicated and hard manpower
- Increasing employee satisfaction
- Increase in marketability
- Reduction in operational costs
- Increasing customer satisfaction
- Improving in internal communication
- Improvement in customer service and relations
- Reducing risks
- Increase in attraction to investors

4.4.2 Simulated results

The model of simulation based on evidence to prove that an integrated system as is key to reduce processing times in TQM business processes with the application of digital technology. The two scenarios used for the model is based on the following;

- No automation and integration
- Automated and integrated system

The model is based on the workflow the Stores Department (receiving) to Quality Department (invoicing), see Figure 21. Currently ABC Manufacturing uses ERP-Epicor system for various departments (Stores, Quality, Production, Supply Chain) in isolation and the system is currently limited to the functional departments. To improve on the current system a trial run on ERP-Epicor system integrating the four departments, Figure 22, to simulate the projected for each of the processes, this trial is tested for a period of four weeks, data is collected in form of time studies and direct observations of optimized processes.

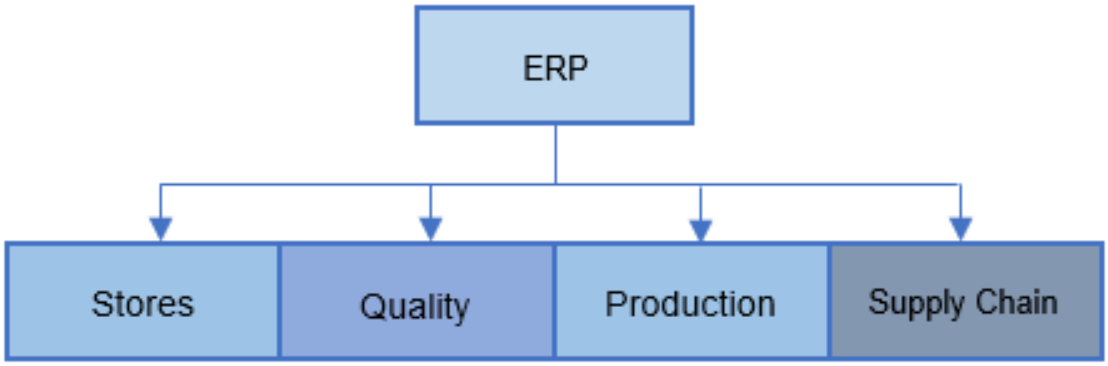


Figure 21: ERP Integration Departments

Source: Data Collection

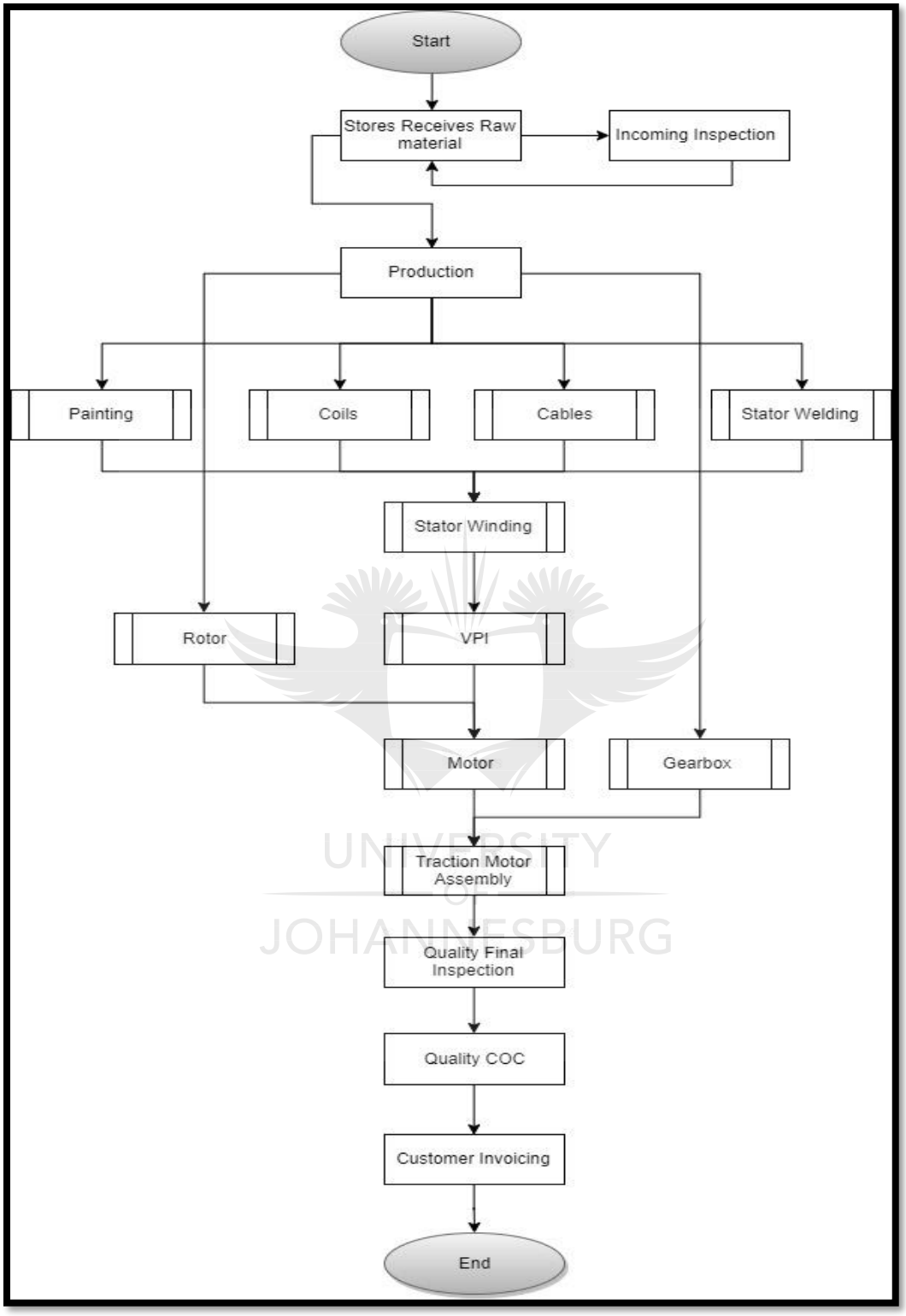


Figure 22: Event with functional perspective

Source: Data Collection

- Stores Department

Total time	22 min per part received
Receive inspection documents from supplier via email	5 min
Verify quantities of delivery and sign receipt	10 min
Send link alert to Quality Department	2 min
Capture information into ERP-Epicor system	5 min

Table 10: Optimized processing time Stores Department

Source: Data Collection

Table 10 above demonstrates the simulated processing time of information in the stores department. The Stores department has an advantage to receiving supplier documents on email and verify documents on a digital gadget, all documents available on the integrated system. The documents are be sent using an alert to the quality department. Quality Department access the documents off the system. The mandate is to reduce the processing time in the stores department. Direct observations method in form of time studies is used to simulate the average time it takes to process the information.

The basic principle of digitalization serves a method of optimization, reducing the processing items from receiving documents from suppliers to capturing information into the ERP-Epicor system.

- Incoming inspection Quality department

Total time	14 min per part
Access inspection sheet on system	2 min
Complete the inspection check sheet	10 min
Send alert to stores on confirmation	2 min

Table 11: Optimized processing time incoming inspection

Source: Data Collection

Quality personnel receive a notification on parts received and to be inspected from stores and be able to access all supplier documents. Access is then granted for inspection sheets on the shared system, complete the sheet and save it, and link it to the part number received in stores. This eliminates the manual printing, scanning and transporting of documents between departments, see Table 11.

- Production department:

Total time	10 min per traction motor unit
Send stores alert on request for parts	2 min
Access and complete the traveler after each process	5 min
Save information in related field	3 min

Table 12: Optimized processing time in Production

Source: Data Collection

- Connect to the MES_Epicor system on the integrated system, create a job card on the system and generated picking list to be linked to stores, where stores receives a notification on what material is required on the shop floor without physical going to stores to submit a printed picklist see Table 12.

- To eliminate printing process control documents and working instructions, operators receive a gadget which they use for all their process activities. A digital system gives the advantage for information to be fully populated and have no filed incomplete. This system eliminates not the labour cost of printing and scanning but also cost of paper used. The daily effort of printing and scanning may be overall eliminated.

- Final inspection quality department

Total time	43 min per traction motor unit
Completing the inspection check sheet	10 min
Taking pictures	20 min
Complete the configuration log	5 min
Compile traveler data packs	5 min
Generate COC and email Supply Chain	3 min

Table 13: Optimized processing time Quality Final Inspection

Source: Data Collection

- Better control of the configuration log, at this the system automatically draws data and information from the production floor. The system eliminates potential duplicates, incomplete records, unsigned records, incorrect data inputting and time to capture information into a configuration log
- Compiling a manual data pack and eliminates keeping of hard copy records, all traction motor drives is configured on the system see Table 13
- When completing a checklist this activity is done on a gadget and not on paper, configuration to the traction motor that is to be invoiced
- Taking pictures is still a heavy process but it is easier to transfer the data onto a configured system where the pictures are linked to the final inspection check sheet
- The system accommodates the generation of COCs, supply chain has access to all COC reports, at any point in time.

- Supply Chain

Access to all Certificate of Conformance documents and any other relevant documents from the integrated system see Table 5 below.

Total time	3 min per traction motor unit
COC from Quality	3 min

Table 5: Optimized processing time in Supply Chain

Source: Data Collection

4.5 Control Phase

The Control phase is the last phase, where the proposed recommendations are prescribed based on the collected data.

4.5.1 Cost vs Processing time

The era of manually processing information and data is slowly being phased out by improved technologies that drive optimization. The optimization leading to improved processes and at the same time offering results within an instant. The level of technology today benefits and supports the entire value chain; engaging ERP, manufacturing and plant systems to support one communication structure in organizations which reflects the TQM supporting all business processes. see Figure 23. This type of integration secures the ideal product dispatching process, prevention of product inefficiencies, less delays and minimal irregularities.

Figure 23: Integrated system in one centralized system

Source: Author`s Compilation

The main challenge is the time spend performing manual activities which have full potential of being automated, a total of 215 min is spend on one drive. Assuming the company is producing fifty traction motors per month the overall time spend is 10 750 min/ month and 129 000 min/ year and 645 000 min in five years. See Table 14.

The associating the time with cost: the non-value add processing time costs company ABC Manufacturing R500 /hr.

1 hour rate @ R500/hr

Cost of Processing time (Manual)			
Description	Time (min)	Time (hours)	Cost
1 traction motor each	215	4	R1,792
50 traction motors @ per month	10750	179	R89,583
600 Traction motors@ 1 year	129000	2150	R1,075,000
3000 traction motors @ 5 years	645000	10750	R5,375,000
Cost of Processing time (Automated)			
Description	Time (min)	Time (hours)	Cost
1 traction motor each	57	1	R475
50 traction motors @ per month	2850	48	R23,750
600 Traction motors@ 1 year	34200	570	R285,000
3000 traction motors @ 5 years	171000	2850	R1,425,000

Table 14:Cost vs processing time

Source: Author`s compilation

The proposed integration system does not only benefit office workers but also employees on the shop floor. Everyone has the advantage to access real time data within seconds on the proposed gadgets. This proposal is still supported by the business process which affects TQM input and outputs.

The original processing times per department, as shown on Table 16 below. A total of four departments which have internal processes that are dependent on each other but are not integrated, with a total of 290 minutes to process information to complete one traction motor assembly. Table 17 below shows the results after applying an integrated system that links all departments and using digital technology to capture data.

Department processing time	Original time (min)	Optimized time (min)
Stores Dept.	35	22
Quality Dept. Incoming inspection	40	14
Production Dept.	115	10
Quality Dept. Final inspection	90	15
Supply Chain Dept.	10	3
Total time (min)	**290**	**93**

Table 15: Optimized processing time per department

Source: Data Collection

The direct total time for processing information for one traction motor exclude the processing time of Stores and Quality (incoming inspection). The two, business process do not have a direct impact on the time it takes to invoice a traction motor. Therefore, the total direct processing times includes production, quality (final inspection) and supply chain, see Table 22.

Department processing time	Original time (min)	Optimized time (min)
Total time (min)	215	57

Table 16: Overall information processing time

Source: Data Collection

The new optimized process reduces the following in the Stores Department:

- Receive supplier documents electronic, eliminates risk of losing documentation
- Eliminate time to hand deliver documents to Quality department send notification on ERP with link
- Increase throughput between Quality incoming inspection and Stores
- Use ERP system to issue and send notification to production
- Reduce time waiting on quality to release parts and documents

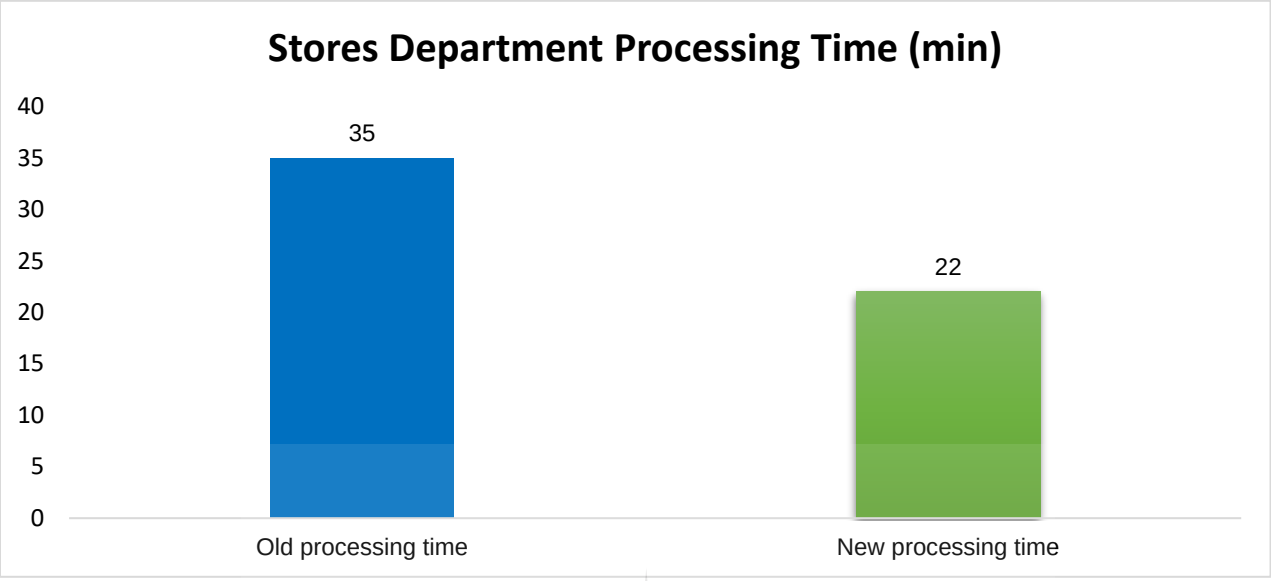


Figure 24: Stores department processing time after the simulation

Source: Data Collection

The new optimized process reduces the following in the Quality department: Incoming inspection

- Eliminate time to hand deliver documents to Stores department send notification on ERP with link
- Use electronic signature
- Eliminate printing of inspection check sheet, access inspection sheet on the ERP
- Capture data into the system
- Eliminate time for scanning by 100%

The new optimized process reduces the following in the Quality department: Final Inspection

- Eliminate printing of inspection check sheet, access inspection sheet on the ERP
- Eliminate time for scanning by 100%
- Capture data into the system
- Traveler pack available on ERP system, no hard copies
- Use system to compile data pack (complete data pack on the system)
- Reduced time access to any documentation on integrated system
- Reduced time to generate Certificate of Conformance

- No duplication on configuration log
- No missing data on travelers
- All traveler signed after each operation
- Eliminate time to request for travelers from supervisors

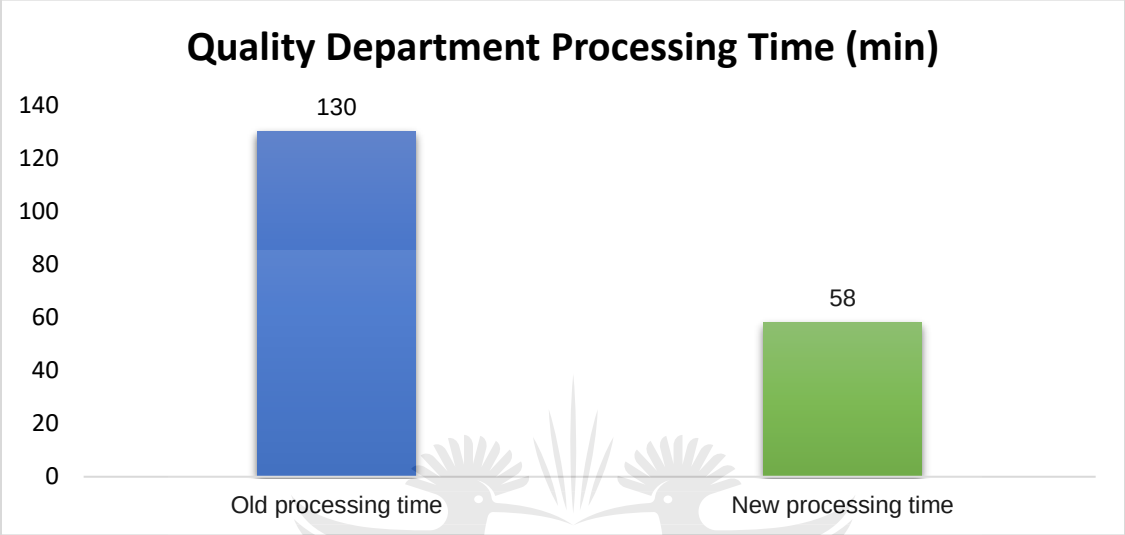


Figure 25: Quality Department processing time after simulation

Source: Data Collection

The new optimized process reduces the following in the production department:

- Eliminate time wasted to hand deliver picklist to stores
- Eliminate time for printing and scanning by 100%
- Process control documents and working instruction accessible on the system
- Reduce time to process information by capturing and not writing
- Reduce labor cost
- Optimize process to request material from stores

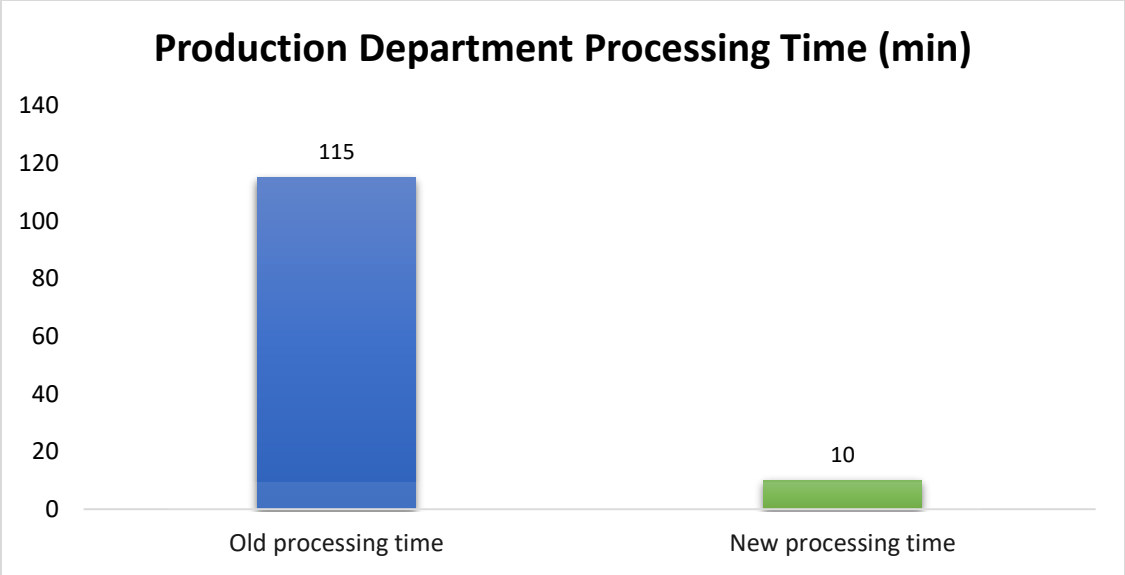


Figure 26: Production department processing time after the simulation

Source: Data Collection

The new optimized process reduces the following in the Supply Chain department:

- Reduce time to access COC, see Figure 29
- Access COC on the centralized system at any given time

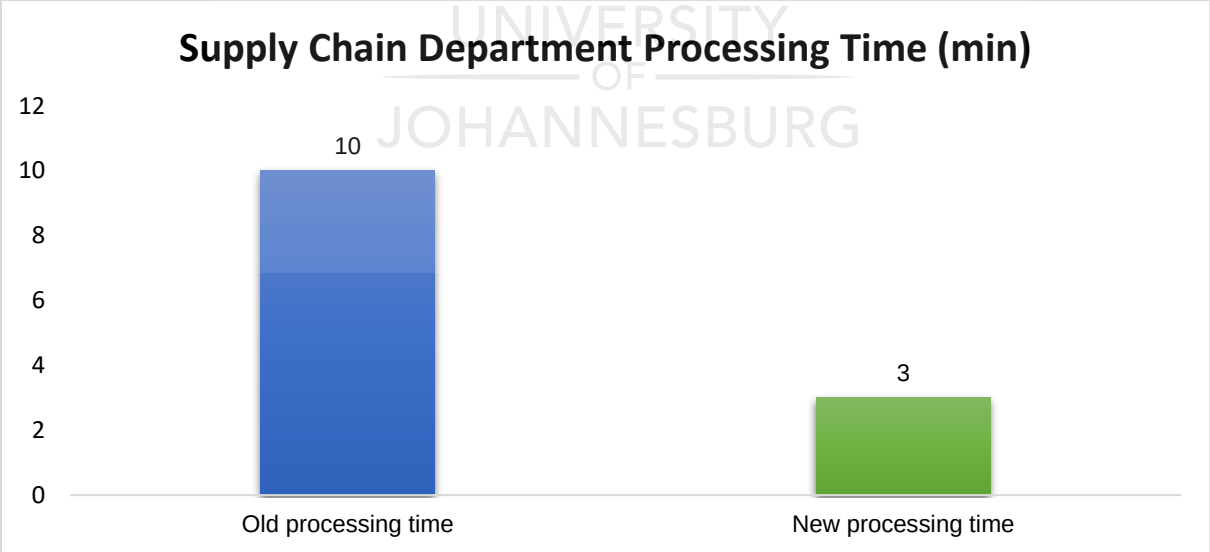


Figure 27: Supply Chain processing time after the simulation

Source: Data Collection

4.5.2 Projected Overall improvements

The model is established according to the business process workflow. The results on Figure 30, show a reduction of 73% on manual information processing.

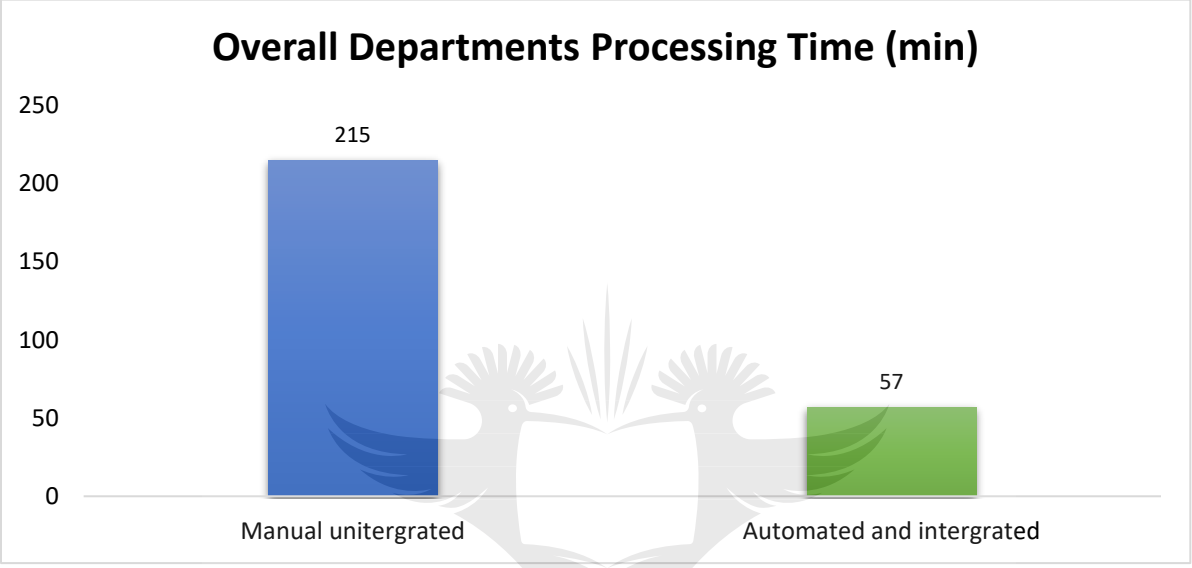


Figure 28: Overall Departments processing time before and after simulation

Source: Data Collection

New digitized system reduces the following

- Processing time estimated to be reduced by 73%
- Less effort to complete documentation, eliminating manual information processing
- Real time data on status of information captured
- The process has been optimized in term of improvements stated above, the model requires less time to cover the work and less checks

The graph below, Figure 31, demonstrates the total time lost comparing between manual system and automated integrated system. The amount is projected from the current minimum processing time that 4 hours @ R500/hr the optimized time is reduced to 1 hour @R500/hr.

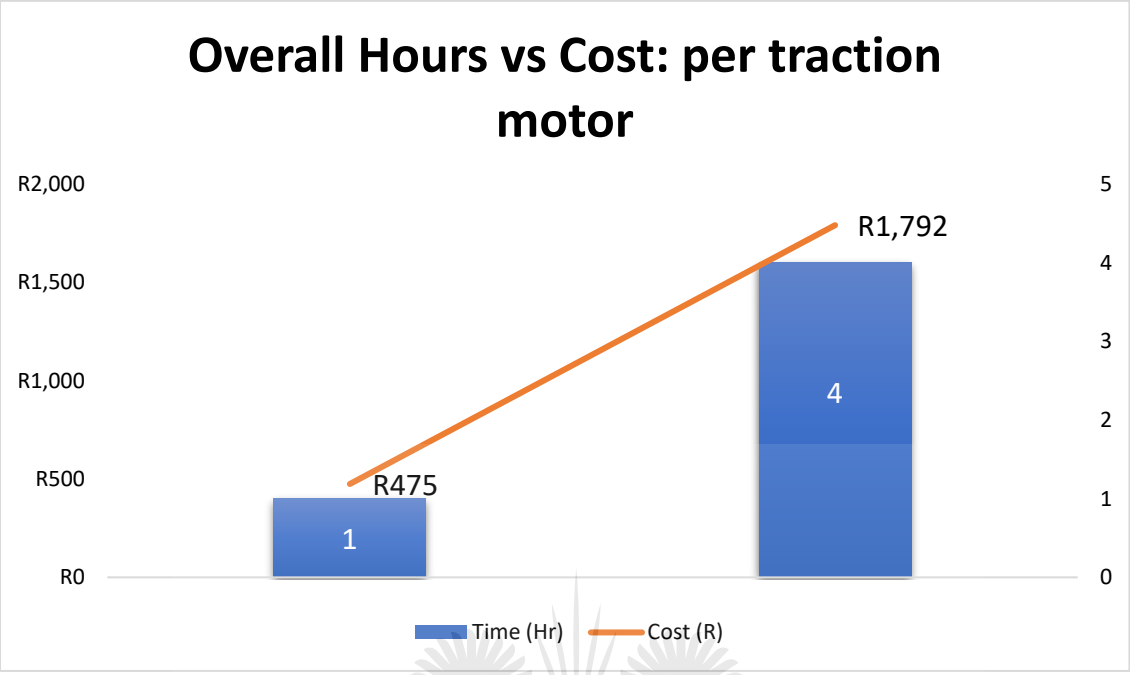


Figure 29: Overall Hours vs Cost per traction motor

Source: Data Collection

4.5.3 Recommendations

Organizations are investing in technology and solutions that help in improving and optimizing their operations. Organizations strive to stay competitive by implementing systems and processes that provide the expected or exceeded customer expectations [99].

The cost of purchasing a tablet valued at R4000. The organization is currently making a loss of R 1 705 000 per year to process data and information manually. If the company invests in purchasing a 100 of the gadgets. A total spends in CAPEX investment of R400 000. This investment cost with a ROI (Return on Investment) and saving of R1 305 000 per year. This solution benefits the organization in integrating their processes and optimizing their processes

The below proposed is the number of tables which are required per workstation to accommodate all shop floor employees to adopt the digital culture, see Table 17 below with details. The impact of this

case study has relevant an eminent side of digital technology which organizations need to take into consideration.

Department	Number of required (QTY)	Cost of tablet (R)
Stores Department	5	R 20 000
Quality: Incoming inspection	5	R 20 000
Production	85	R 34 000
Quality: Final inspection	5	R 20 000
Total	**100**	**R 400 000**

Table 17: Proposal for tablets for shop floor employees

Source: Author`s compilation

4.5.4 Summary

The objective of the study is to:

- help production industries to successfully apply digital technology to support TQM in business processes. The focus on data collection and capturing live data is still a challenging factor that many organizations are facing in the manufacturing industry.
- The aim of this study is to realize digital technology benefits, the eliminate manual data capturing and accelerate information that affect TQM business processes.
- generate knowledge from existing industries that have applied different TQM business processes and identified the need for integrating business functions into one configured digital technology system.

Chapter 5: Conclusion

The application of digital technology provides new opportunities for any business process to create a co-efficient workflow and chain model. Digital technology and TQM concepts present a new vast opportunity of small, medium and large organizations in different sectors.

The integration of TQM business processes and digital technology, the combination creates an overall system that supports organizations` objectives and at the support the system dependency and quality of information needed. The system benefits: reducing processing time on activities that do not add value, reduce impact of “human factor”, focuses on value-add activities and eliminate non-value add activities, and increasing efficiency of the organization`s Quality Management System.

Below as some of the objectives and how those researches fulfilled throughout the research process:

- Understanding TQM and its functions: this include the inputs and outputs of business processes
- Integration of TQM business processes: this is having one configured system of all business processes which support the supply chain
- Application of digital technology in TQM business processes: industry 4.0 enhancing innovation into business process and the global market

The simulation provide indication that support innovative technology and integration of business processes. The design of this application and integration style provided in this research paper delivers on digital technology for any organization. The presented results of automated simulations process reelect son the overall time saved and the processing time between department under one integrated system increase. The findings in this research helps to streamline processes and find ways to optimize on current systems.

In order to achieve the research objectives, three research questions were proposed as follows:

a) What is the international global practice of Total Quality Management and what are TQM functions within an organization? Chapter 2, shows detailed study of TQM global practice and its benefits. TQM functions used in business organizations has been defined, adaptation proven in the results section in Chapter 4.

b) What is the relationship between digital technology and TQM functions in different organizational sectors? Organizations are encouraged to undertake in integrating of various business processes and improve on related business process that depend on eachother for real-time collaboration with supporting business functions [100]. This question has been answered in the case study in Chapter 4. This chapter shows the functional areas of ABC Manufacturing with various business processes and using digital technology isolated from other departments.

c) How is digital technology applied in a TQM business process within a manufacturing firm? The case study presented for the purpose of this research represents different functional departments which includes lower level sub-functions at an operational level. The case study represents data of processes which are not integrated and also simulated results of optimized process. This question has been answered by the case study simulation presented in Chapter 4.

The following is list for recommendations for further research:

- Having knowledge that South Africa is the 47th country of 63 countries based on Digital competitiveness, what is the countries approach to improve its stance in the next coming years
- Developing a cheaper solution to implementing digital technology in SMEs (Small Medium-sized Enterprises) with the support of government
- Further research is required to exhaust uses to digital technology where it has never been introduced.

Appendix A: Time study per activity in departments (Before improvement)

Stores Department

Description	1	2	3	4	5	6	7	8	9	10	Total time (min)
Receive documents from supplier and review • Review if correct documents have been submitted	9	11.1	10.2	8.9	8.9	9.1	10.1	9.4	10.5	9.9	9.71
Verify quantities of delivery and sign receipt • Count number of parts • Sign receipt	8.7	10.1	10.3	9.9	10	9	10.1	9.8	10.3	10.1	9.83
Deliver documents to quality department • Walk to quality department and back to stores	10	8.9	9	9.2	8.9	9.7	9.5	9.9	10.5	10	9.56
Capture parts into ERP-Epicor system	5	5.8	6	5.9	5.7	6	5.2	5.4	5.2	5	5.52
										Total processing time per part	35

Quality Department: Incoming inspection

Description	1	2	3	4	5	6	7	8	9	10	Total time (min)
Print inspection sheet • Accessing inspection form in server and print • Collect inspection sheet from printing station outside the quality department	5.1	4.9	5.1	5	5.2	5	4.8	4.7	5.1	5.2	5.01
Complete the inspection check sheet (manually) • Write down dimensions after measuring each size	19.7	20.1	20.3	20	19	20.5	20.1	19.9	19.8	21	20.04
Deliver signed documents to stores	9.8	11	10	9.4	9.8	10.1	9.2	9.5	10	10	9.88

• Walk to stored department and back to quality											
Scan and save inspection sheets • Walk to scanning station and back • Scan each page • Access emails • Save inspection sheet into the drive server	10	12	10.5	11	10.2	10.8	10	10.1	10.4	10	10.5
										Total processing time per part	45

Quality Department: Final inspection

Description	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Total time (min)**
Print inspection sheet • Accessing inspection form in server • Collect inspection sheet from printing station outside the quality department	5	5.1	5.5	4.9	4.7	5	5.2	4.9	5.4	5.1	5.08
Complete the inspection check sheet (manually) • Write down results after completing each check	14.8	14.5	13.9	14.2	14	14.5	14.5	14.8	14.9	15	14.51
Take pictures • Transfer pictures and save picture in server	22	20.5	21	21	20.1	19	20	20.5	20.7	20	20.48
Scan and save inspection sheets • Walk to scanning station and back • Scan each page • Access emails • Save inspection sheet into the drive server	11	9.8	10.2	10.5	10	10.1	9	9.8	10.1	10.2	10.07

Complete the configuration log • Use travelers form all departments to capture information on the config log • Where information is missing request production to complete	8.8	9.2	10.5	8.9	7.8	10.5	11	8.5	10.8	9.9	9.59
Compile traveler data packs • Access travelers from pigeonhole • Link each traveler according to build configuration • Where traveler is missing request from production	20.2	21	25	20.1	20	19.8	19	17.5	20.1	19.9	20.26
Generate COC and email Supply Chain • Access form on server capture information of traction motor drive • Access signature for approval • Save and send email to Supply Chain	8.9	9.1	10.2	9.4	9.8	8.8	9.5	10.1	9.3	10.5	9.56
										Total processing time per part	90

Production Department

Description	1	2	3	4	5	6	7	8	9	10	Total time (min)
Print picklist to collect parts from stores	5.2	5	5.1	4.8	4.5	4.8	4.6	4.7	5.2	5.1	4.9
Walk and submit picklist to stores	15.5	14.9	15.2	15	14.5	15.3	15	15.8	14.8	14.5	15.05
Print new travelers and collect them from the printer	18	20.5	19.5	20.1	20	19.5	21	20.4	20.1	20.3	19.94
Complete the traveler after each process (manually) • Sign after completing each section • Page through traveler and verify completeness and correctness	15	14.9	15.2	15.2	16	15.5	16.2	17.5	14.5	14.6	15.46
Scan and save traveler • Walk to scanning station and back • Scan each page • Access emails • Save traveler into the drive server	42.5	45	45	49.5	45.1	40	42	46	47.5	44.5	44.71
Place traveler in the temporal repository in Quality • Walk to the quality department	13.9	14.5	15.1	15.2	15.8	14.7	14.2	15	15.2	15.1	14.87
										Total processing time per part	115

Supply Chain Department

Description	1	2	3	4	5	6	7	8	9	10	Total time (min)
Request COC from Quality • Send email or call quality inspector to send COC	8	5	10.5	6	15	15.5	10.2	9.5	8.5	7	9.52
										Total processing time per part	10

Appendix B: Time study per activity in departments (After improvement)

Stores Department

Description	1	2	3	4	5	6	7	8	9	10	Total time (min)
• Receive inspection documents from supplier via email	5.3	5	5.1	4.8	4.2	4.2	4.5	5	5	5.6	4.87
• Verify quantities of delivery and sign receipt	9.1	9	9.8	9.2	10.2	10	11	11	10.2	10.2	9.97
• Send link alert to Quality Department	2.4	2.5	2.3	2.1	2	1.8	2.3	2.5	2	1.9	2.18
• Capture information into ERP-Epicor system	4.8	5.2	3.9	4.9	4.8	5	5.4	5.6	5.1	5.5	5.02
										Total processing time per part	22

Quality Department: Incoming inspection

Description	1	2	3	4	5	6	7	8	9	10	Total time (min)
• Accessing inspection sheet on the system	2.3	2.2	2.4	2.5	1.9	2	1.9	2.01	2.1	2	2.131
• Complete the inspection check sheet	10.5	10.5	8.9	9.5	9.2	10	11.2	10	10.5	10.5	10.9
• Send alert to Stores on confirmation	2.5	2.2	1.8	1.5	2	1.8	2.1	2.3	2.2	2.2	1.9
										Total processing time per part	14

Quality Department: Final inspection

Description	1	2	3	4	5	6	7	8	9	10	Total time (min)
• Completing the inspection check sheet	10.5	11	10.5	12	10	10.2	10.5	10.2	10	10.1	10.5
• Take pictures	20.1	19.8	19.5	23	20	20.5	21	19.5	18.5	18.5	20.04
• Complete the configuration log	5.5	5.5	5	5.4	5.8	5.2	5	5.4	5.5	5.5	5.38
• Compile traveler data packs	4.8	5	4.9	5	4.8	5.2	5	5.8	5.8	5.8	4.81
• Generate COC and email Supply Chain	3.5	4	4.1	3	4.5	3	3.4	3.2	4.2	4	3.39
										Total processing time per part	43

Production Department

Description	1	2	3	4	5	6	7	8	9	10	Total time (min)
• Send stores alert on request for parts	3	2.5	3.1	2.5	2.8	2	2.1	2.4	2.1	2	2.45
• Access and complete the traveler after each process	5.3	5.2	5.6	5	5.2	5.1	5.1	5.5	5	5	5.2
• Save information in related field	2.5	2.8	3	3.4	3.5	3.1	3.2	3	3.6	3.1	3.12
										Total processing time per part	10

Supply Chain Department

Description	1	2	3	4	5	6	7	8	9	10	Total time (min)
• Access COC from ERP system	2.1	2	2.1	2.3	2.5	2	2.1	2	1.9	1.8	2.08
										Total processing time per part	2

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