Title: **Assessment of Quality Management in Major Projects in the Mining Industry in Botswana**

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CANDIDATE'S DECLARATION

I, Odirile Boniface Pitswe, student number 1912971, declare that this research report is my own unaided work. It is being submitted to the Degree of Master of Science in Mechanical Engineering to the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination to any other University.
I hereby further declare the following:

- I am aware that plagiarism (the use of someone else's work without their permission and / or without acknowledging the original source) is wrong.
- I confirm that the work submitted herewith for assessment in the above course is my own unaided work except where I have explicitly indicated otherwise and referenced the owner of any piece of work that I may have used.
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Signed:  on this 27th day of March 2024.

ABSTRACT

While project performance is generally evaluated in terms of schedule, cost and quality performance, guidelines for project quality management are lacking, (Steyn and Nicholas, 2008). The Botswana mining industry is faced with problems of engineering projects which don't meet the expected outcomes and most of the problems emanate around quality management and quality defects. This research project involved the assessment of quality management in major engineering projects in the Botswana mining industry by evaluating the level of adoption and implementation of quality management systems in major engineering projects, identifying the major causes of project failure, and evaluating the effectiveness of quality management system as employed in major capital projects. The research was focused mainly on Debswana Diamond Mining company as the major mining house in the country, with an objective to assess the maturity level of the company's quality management system (QMS) and identify opportunities for improvement.

A mixed method approach was used which involved archival research and survey research, the results of which were triangulated to corroborate the findings and remove bias. Archival research was conducted using the company document repository to review project retrospect reports, (Lessons learnt reports) and identify problems experienced during the implementation of different projects. These were correlated with common causes of project failures as identified in the critical literature review and cross referenced against survey results to further confirm them.

The results indicated that the maturity level of the Quality Management system is at level 4 (quantitatively managed), where processes are measured and controlled. Gaps were identified that if rectified would move the maturity to level 5 (optimizing), where the focus would now be on process improvement. The gaps are mainly around operationalisation, lower-level employees training on quality management, optimisation of shared resources especially subject matter experts like project engineers, key stakeholder management, involvement and participation from end users and operational teams.

The study came up with the top five (5) major causes of project failure being:

1. Shared resources and subject matter experts get overstretched between different projects and end up neglecting quality assurance.
2. Poor stakeholder management.
3. Lack of stakeholder involvement and participation in the project.
4. Inexperienced project team.
5. Unclear statements of expected quality outcomes.

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CHAPTER 1: INTRODUCTION

1.1 Research background

The Central Intelligence Agency, (CIA) World fact book stated that the mining industry plays a pivotal role in the economy of Botswana, particularly the diamond mining sector. The fact book further posits that mineral extraction, principally diamond mining, dominates economic activity, though tourism is a growing sector due to the country's conservation practices and extensive nature preserves. Until the global recession, Botswana maintained one of the world's highest economic growth rates since independence in 1966. Diamond mining fuelled much of the economic expansion and currently accounts for one-quarter of GDP, approximately 85% of export earnings, and about one-third of the government's revenues, (The world fact book; Botswana, CIA).

Therefore, the researcher, based on his experience and with insigths from literature, assumes that large capital projects in the mining sector have a direct bearing on the future of the country's economy and hence the quality of the engineering projects delivered is of paramount importance. Major investment in capital projects in the mining industry have a huge impact on the future and sustainability of the mining sector which in turn has a major bearing on the economy of the country. The quality of the product of these major engineering projects is critical and they determine the cost of investment, longevity, and durability of the product. Furthermore, the quality determines whether the product serves its intended purpose or not which translates to the economic viability and sustainability of the mining industry and the country's economy at large. Ullah et al. (2023) state that a project's failure or success has effects that go well beyond the boardrooms and project management offices where it is planned and carried out. They further posit that projects are complex endeavours that involve a large number of stakeholders, each with vested interests, whether they are related to infrastructure development, technical developments, or organizational transformations. Beyond the limits of industries, geographies, and economies, it is of utmost importance to comprehend the effects of project failure on stakeholders. It is a space where the interplay of economic effects, reputational harm, legal ramifications, impacts on employee well-being, stakeholder relationships, innovation and growth, and community and environmental effects reshapes the landscape of organizations, communities, and countries. Of greater concern to Ullah et al. (2023) is that the effects of project failure on stakeholders manifest themselves on a global stage. The effects of a project failure in one area of the world are felt in other parts of the world because of how linked today's world is, as supply chains cross continents and investments cross borders.

Global financial markets react to company failures, investors on different continents endure the burden of value deterioration, and global corporations' reputations are on the line. International best practices in project management and risk mitigation are necessary because of the wide-ranging legal repercussions and the widespread effects of poorly managed projects on stakeholders worldwide, (Ullah et al. 2023). These concerns have prompted the researcher to venture into this research topic.

1.2 Research Context

Debswana Diamond Company (Pty) Limited (Debswana) was established in 1969 and is one of the world's foremost diamond producers by value and volume. The company operates four diamond mines: Jwaneng, Orapa, Letlhakane and Damtshaa Mines (the latter three are grouped under the acronym OLDM) and has a Corporate Centre in Gaborone, (Debswana website, 2024)

Debswana is an equal partnership between the Government of the Republic of Botswana (GRB) and the De Beers Group of Companies. The diamonds produced from the four mines are sold to De Beers and the Okavango Diamond Company, and Debswana is the biggest contributor to the De Beers Group rough diamond production, (Debswana website, 2024). Debswana is a major part of the national economy of Botswana and makes a significant contribution to country's gross domestic product, foreign exchange earnings and government revenue. It is one of the largest private sector employers, with more than 5 000 employees and 6 000 contractors working at its operations, (Debswana website, 2024).

Debswana is a major contributor to the national economy of Botswana – contributing significantly to the gross domestic product, foreign exchange earnings and government revenue. It is one of the largest private sector employers, with over 5200 employees. Debswana is also the biggest contributor to the De Beers Group rough diamond production, (Debswana website, 2024).

The research was conducted in the projects management department across all the three (3) Debswana operations being Jwaneng Mine, Orapa Letlhakane and Damtshaa Mines (OLDM) and Debswana Corporate Centre (DCC) projects office. According to the Debswana website, as accessed on the 18th of March 2024, each operation has a Project Management (PM) Department under which site-specific projects are initiated and executed from. These site-specific projects are those that fall within the 5-year Strategic Business Plan (SBP). Any project that is within a horizon of more than 5 years is managed from the Head Office Project Management Office also known as Horizon 2 (H2) Project Department. The H2 Projects is a department on its own, centred in the Head office and looks after all the three operations' projects being Jwaneng, Orapa and Gaborone. Major projects at H2 include long term mine expansions, digital transformation projects, exploration projects to

mention a few. Operational projects will be strategic stay-in-business projects like major shutdowns, equipment upgrades, equipment replacements and rebuilds et cetera, (Debswana intranet, 2024). According to information sourced from the company website, there are some major projects currently going on or under development towards the future longevity, sustainability, and profitability of the business. These projects include the Jwaneng underground mining project (and) the Orapa Cut 3 pit expansion project.

According to the Debswana corporate website, Jwaneng mine, also known as the prince of mines, was discovered in southern Botswana in 1972 [and] became fully operational in August 1982. It is the world's richest diamond mine by value due to its substantially higher dollar per carat obtained from its gems [and] it contributes about 60-70% of Debswana's total revenue. The current pit operations activity is mining the cut 9 waste and ore productions.

The Jwaneng mine has been operating in a sustained, profitable open pit mining environment for over fifty years and it is forecasted that the same favourable business climate will prevail over the next 15 to 20 years. Notwithstanding this, for Jwaneng Mine, the post Cut 9 business case evaluation paints a different picture which proves that no further open pit cutback will yield a positive business case for the mine. This resulted in the direction of future Jwaneng mining projects being directed to underground alternatives, (Debswana website, 2024).

Debswana intends to develop a safe and viable underground mine to sustain production of diamonds after Cut 9 open pit operations. It will be developed based on the latest proven technology, global benchmarks, and full adherence to sustainability imperatives. This includes the journey to carbon neutrality for the organization. This operation will exploit resources at ever increasing depth, down to approximately 1000m below ground level, where significant diamond resources remain after Cut 9. It will use mass mining methods for the underground mine such as block-, sub-level and incline caving. With the end of open pit operations, expected to be in 2032 when the current Cut 9 reaches its economic limit, the remaining diamond resources from the three kimberlite pipes (Centre, North and South) can sustain current production levels and further extend the Jwaneng mine life beyond 2050, (Debswana website, 2024).

Insights from the Debswana website show that a phased approach has been adopted as the lowest risk strategy to develop an underground mine to meet the schedule to sustain production after end of open pit mining. This approach requires an Early Exploration Access Decline for implementation in 2023, which will provide the platform to launch Phase 1 Mining of the indicated resource starting

2028 to allow for full ramp up by 2032. It will simultaneously allow for drilling of inferred resources at depth for the acquisition of critical resources and geotechnical data for later mining phases.

The Orapa, Letlhakane and Damtshaa Mines, collectively called O.L.D Mines form the second set of Debswana operations in central Botswana. Orapa Mine is a conventional open pit mine, situated 240km west of Francistown discovered in 1967 [and] became fully operational in July 1971. Four small pipes were discovered 20km east of Orapa mine and make up the Damtshaa operation. This, together with the Letlhakane Mine operation, are satellite mines managed through the Orapa operation. Damtshaa was also discovered in 1972 [and] became fully operational in August 2003. Letlhakane mine is situated 50km from Orapa and 190km west of Francistown. It was discovered during the sampling process at Orapa when it opened in 1971 [and] became operational in 1975. The Letlhakane mine ceased its open-pit operations in 2017 as planned. Then a major project to extend the life of mine to 2043 was commissioned and is now operational. It is called the Letlhakane Tailings treatment plant which is designed to treat coarse tailings [and] has a capacity of producing 800,000 carats per annum, (Debswana website, 2023).

Orapa is an open-cast operation currently mining its cut 2 area. This means that to get to the diamond-bearing kimberlite rock, large amounts of waste rock must be removed first to create mineable access to the ore body. This is done through a series of what is called “cuts” in mining terms, (Debswana website 2024). A cut is the area that must be excavated to reach an ore deposit. It extends outward from the shaft or ramp, (Jumabayeva et al, 2023)

A detailed study is underway to extend the life of the mine beyond the current Cut 2. Studies are at pre-feasibility stage and will inform the various parameters for Cut 3. The current Life of Mine, which only includes Cut 2, extends to early 2030's. Cut 3 follows on from Cut 1 and 2 and this life extension will include necessary infrastructure and latest technology to mine and process the kimberlite as safely and efficiently as possible, anticipated to extend the life of Orapa mine pas 2050, (Debswana website, 2024).

These large capital projects are all managed under the Debswana Project Management Office Department from a central point being the head office, known as Debswana Corporate Centre (DCC), (Debswana website, 2024).

Figure 1: Picture showing a pit expansion "cut" in an open pit mine

Figure 2: Locations of Debswana Diamond Mines in Botswana. Source: 2017 socio-economic assessment toolbox (SEAT) report-OLDM

1.3 Problem Statement

The mining industry in Botswana has been experiencing quality related problems in major projects over the last few of years. According to the literature reviewed and evidence retrieved from archival research, these quality problems are often realised at the last stages of the project life cycle, (execution, commissioning, and handover), and they negatively affect the project sponsors/owners in terms of the overall quality of the product delivered by the projects, (Orapa 2017-2020 SEAT report,2020).

Research provides evidence that many projects face out of scope quality problems which in most cases result in costly scope creep, extended project timelines, escalated costs, and compromised safety aspects (Siriram, 2017). This emanates from the fact that quality management was not factored in at the beginning of the project and if this is not addressed, the project procuring entity, or the mining company end up facing the dire consequences of poor quality in the project product, (Lessons learnt report, Jwaneng Cut 8 project, 2011). Addressing the issue of project quality management in its entirety, (quality planning, quality control and quality assurance), by the mining industry will have positive benefits for mining companies and reduce the cost of quality, (Rose, 2017).

1.3.1 Research purpose

According to the report on Major projects lessons learnt, (Lessons learnt report, Jwaneng Cut 8 project, 2011) there are multiple problems associated with major projects at Debswana. Some of the problems are managed but result in costs incurred, scope variations, and delayed project deliveries. The other key problems identified in the report is poor quality and noncompliance to the quality management plan as outlined in the project charter.

As a result of the challengers in project quality management at Debswana, it is important to investigate the adoption and implementation of quality management in major projects at Debswana mining operations.

1.4 Research Questions

1.4.1 Critical research question (CRQ)

What is the status of adoption and implementation of quality management systems (QMS) in Botswana mining companies in relation to major projects.

1.4.2 Research Objectives

Overall objective: To evaluate the status of the adoption and implementation of quality management systems in Botswana mining companies in relation to major projects.

The research objectives are as follows:

a. Determine the major causes of project failures related to quality management in Botswana Mining Industry.
b. Investigate the level of adoption and implementation of the quality management system (QMS) in projects in Botswana Mining industry.
c. Evaluate the effectiveness of quality management systems and processes in Botswana Mining Industry and identify gaps for improvement.

1.5 Summary of Research Method

This research framework utilised research method of qualitative (archival research) and quantitative (survey) research. This method is usually used by researchers when they want to validate results, confirm, [or] corroborate quantitative results with qualitative findings, (Creswell, 1999).

The survey questionnaire was focused on Debswana Diamond Mining Company. Close ended questions were developed and sent out to respondents to solicit their answers which were later analysed to evaluate the effectiveness of the quality management system in Debswana projects and the maturity level thereof. The questionnaire was further used to determine the causes/reasons for projects failure in Debswana. To further complement the survey method, secondary data was collected through historical archive analysis on the quality management system for Debswana, quality standards and procedures as well as the lessons learnt reports (LLRs) and project retrospect reports which are normally carried out and documented at the end of every critical project.

Ethics clearance was applied for and granted. Ethical issues were addressed in the following manner when carrying out the study:

a. Participation by respondents was voluntary.
b. Survey questions did not contain any offensive, discriminatory or any unacceptable language.

c. Privacy and anonymity of respondents was highly maintained.
d. The works of other authors that were used in any part of the study have been acknowledged and referenced.
e. The author maintained high levels of objectivity in all discussions and analyses.

The ethics clearance number from the school is **MIAEC 101/20.**

1.5.1 Delimitations of Scope

Research projects, no matter how well organised they are, will always be bound by certain limitations and assumptions. The limitations for this study include but not limited to:

a. Sample size: the study is limited to Debswana diamond mining company projects department. This limits the amount of information received based on the sample size.
b. Prior research: there is lack of research that has been done on the quality management system evaluation for Debswana projects. Therefore, relevant data that could be used as the basis for this study is limited to Debswana internal reports.

1.6 Outline of Chapters

The research report is divided into 7 chapters as outlined below.

Chapter one (1) introduces the research background and delves deeper into the research context. It continues to outline the problem statement, the research questions and explains the research method.

Chapter two (2) is the literature review chapter which reviewed information sources pertaining to project management in general, project quality management requirements and Quality management systems in totality. This chapter was meant for the researcher to gain insights into the Project quality management space, and it further helped to identify problems and eventually formulation of the research problems and research questions.

Chapter three (3) outlines the research methodology that was adopted for the research project covering the research design, the research philosophy and the associated research instruments that were employed in the research exercise.

Chapter four (4) is the results and data analysis chapter where data interpreted into information that could be analysed and shared with the target audience in a palatable and understandable format. It

covers data analysis of archival and survey research results and the triangulation thereof to corroborate the findings and remove bias.

Chapter five (5) is the discussions of the results and outlines any unexpected findings that arose during the research journey.

Chapter six (6) outlines the researcher's recommendations for future research and actions to address identified possible issues.

Chapter seven (7) outlines the appendices.

Chapter eight (8) is a list of reference material used to carry out the research.

CHAPTER 2: LITERATURE REVIEW

This chapter presents a detailed critical review of existing literature on project management literature as well as quality management literature. The review further investigates why major projects fail in the mining industry at large and it focusses on the Botswana mining industry.

2.1. Project Management

The PMBOK guide (2017) defines project management as the application of knowledge, skills, tools, and techniques to project activities to meet the project requirements. Project management involves appropriate application and integration of the management processes identified for the project. Project management enables organizations to execute projects effectively and efficiently, (PMBOK Guide, 2017). The latest edition of the PMBOK guide (2021), further elaborates that project management refers to guiding the project work to deliver the intended outcomes using a broad range of development approaches including predictive, adaptive and hybrid approach. A development approach is the means used to create and evolve the product, service, or result during the project life cycle. A predictive approach is useful when the project and product requirements can be defined, collected, and analysed at the start of the project. This may also be referred to as a waterfall approach. This approach may also be used when there is a significant investment involved and a high level of risk that may require frequent reviews, change control mechanisms, and replanning between development phases. The scope, schedule, cost, resource needs, and risks can be well defined in the early phases of the project life cycle, and they are relatively stable. This development approach allows the project team to reduce the level of uncertainty early in the project and do much of the planning up front, (PMBOK Guide, 2021). The PMBOK Guide, 2021 goes on to explain adaptive approach as being useful when requirements are subject to a high level of uncertainty and volatility and are likely to change throughout the project. A clear vision is established at the start of the project, and the initial known requirements are refined, detailed, changed, or replaced in accordance with user feedback, the environment, or unexpected events. A hybrid development approach is a combination of adaptive and predictive approaches. This means that some elements from a predictive approach are used and some from an adaptive approach are used. This development approach is useful when there is uncertainty or risk around the requirements, (PMBOK Guide, 2021).

The project management (PM) discipline has been developed worldwide through the practice and theories implemented in various types of projects, (Abdul-Samad et al, 2021). Prominent organizational bodies such as Project Management Institute (PMI), International Project Management Association (IPMA), Central Computer and Telecommunications Agency (CCTA), Association for Project Management (APM), Engineering Advancement Association of Japan (ENAA) and International Organization for Standardization (ISO) have outlined ways to practice project management [and] achieve project success, (Abdul-Samad et al, 2021).

In project driven organizations, projects are a means to create value and benefits. In today's business environment, organizational leaders need to be able to manage with tighter budgets, shorter timelines, scarcity of resources, and rapidly changing technology, (PMBOK Guide, 2017). The business environment is dynamic with an accelerating rate of change, (PMBOK Guide, 2017). To remain competitive in the world economy, companies are embracing project management to consistently deliver business value, (PMBOK Guide, 2017).

A project has a defined goal, a purpose with well-defined end-items, deliverables, results, or products to achieve specific benefits within a scheduled time frame, (Steyn and Nicholas, 2008). The most prominent feature about project management is the role of the project manager – the individual who has overall responsibility to plan, direct, and integrate the efforts of everyone involved in the project (stakeholders) to achieve the project goal, (Steyn and Nicholas, 2008). The PMBOK guide (2021) emphasize that projects do not simply produce outputs, but more importantly, enable those outputs to drive outcomes that ultimately deliver value to the organization and its stakeholders.

Projects need clear direction from customers and end users regarding project requirements, outcomes, and expectations, (PMBOK Guide, 2021). In adaptive and hybrid project environments, the need for ongoing feedback is greater because the project teams are exploring and developing product elements within specific increments. All projects require management to plan, organize and interrogate resources and tasks to achieve the organizations' goals, (Nicholas and Steyn, 2017). Another function of management in projects is directing and motivating people to attain the goal, [which] is a leadership function, (Steyn and Nicholas, 2017).

2.1.1 The Systems approach

Steyn and Nicholas, (2017), describe project management as a systems approach to management [in which] a project can be thought of as a system or a collection of elements like work tasks, resources,

and stakeholders aimed at achieving some goal. They go on to allude that the focus of the systems approach is to optimize the overall system to achieve the goal. A project can be conceptualized as a system of people, equipment, materials, and facilities organized and managed to achieve a goal in a systems approach. Work done in projects is often done for the purpose of creating systems, and such projects commonly employ methodologies such as systems analysis and systems engineering, (Steyn and Nicholas, 2017). The systems approach is a way to visualise and analyse physical things and conceptual systems, but more than that it is an approach for doing things, a framework for abstracting problems, solving problems, and making decisions, (Steyn and Nicholas, 2017). The term system refers to an organised set of ideas or theories or a particular way of doing something, (Oxford Advanced Learner's Dictionary, 2015).

As defined by Steyn and Nicholas, (2017), a system is an organized or complex whole; an assemblage of things or parts interacting in a coordinated way. The parts can be physical entities, or they can be abstract or conceptual. Beyond being an assemblage of parts, however, a system has three (3) other features:

a. Parts of the system affect the system and are affected by it.
b. The assemblage of parts does something; it serves a purpose or a goal.
c. The assemblage is of particular interest.

One feature of the systems approach is the concept of life cycle, which is the basic pattern of change that occurs throughout the life of a system. Two ways the systems approach accounts for this are to recognise the natural process that occurs in all dynamic systems and incorporate that process into the planning and management of systems. The practice of project management does both, (Steyn and Nichols, 2017). Projects follow a cycle called the project life cycle. Each project has a starting point and progresses towards a predetermined conclusion. During this time, activity in the project continues to grow, reaches a peak, and then declines. Managing the project life cycle requires special treatment.

2.1.2 The standard for project management

As an American National Standards Institute (ANSI) standard, The Standard for Project Management was developed using a process based on the concepts of consensus, openness, due process, and balance, [to serve as] a foundational reference for the Project Management Institute's (PMI's) project management professional development programs and the practice of project management, (PMBOK guide, 2017). Because project management needs to be tailored to fit the needs of the project, the standard and the guide are both based on descriptive practices, rather than

prescriptive practices. Therefore, the standard identifies the processes that are considered good practices on most projects, most of the time, (PMBOK Guide 2017).

The standard for project management identifies project management principles that guide the behaviours and actions of project professionals and other stakeholders who work on or are engaged in projects, (PMBOK Guide, 2021). It applies regardless of industry, location, size, or delivery approach [and] describes the system within which projects operate, including governance, possible functions, the project environment, and considerations for the relationship between project management and product management. Projects exist within a larger system, such as a governmental agency, organization, or contractual arrangement (to) create value for stakeholders, (PMBOK Guide, 2021).

2.1.3 Why do projects fail?

A significant share of projects fails with respect to both producing the intended effect and achieving the expected business results (Hallgrim et al, 2015). Siriram (2017) has stated that many firms face out of control projects and many reports huge losses. Firms are hampered with many failures in project management, and the causes for these failures vary e.g. embedding of project management initiatives, poor quality, cost and schedule slippage, immature processes, adherence to processes, coordination of information flow, knowledge transfer and trust in project relationships, (Siriram, 2017). Projects fail because of lack of competency or knowledge in project management as well as corruption, poor policy planning, and implementation, and their complex contexts. (Lavagnon and Saint-Macary, 2014). Poor performance in projects affects a company's performance and competitive position, (Siriram, 2017). The attempt to get a more complete understanding of why projects fail has proven to be a difficult task for both researchers and practitioners, (Pinto, 1990).

2.2 Project Quality Management

In the 1950s quality was viewed as the process of inspecting products that had already been produced and to separate the good products from the bad products, (Rose, 2014). In the current business environment, so the thinking goes, you must prevent defects and failures rather than inspect for them, i.e., you cannot correct a wrong by inspection, (Steyn and Nicholas, 2018). Steyn and Nicholas continue to allude that processes must be built in, to ensure things are done right the first time, every time, and (inculcate) a culture where everybody is quality focused.

The key to project quality lies in making a more effective, meaningful transfer of proven quality methods to a general project management domain, (Rose, 2014). Rose further states that 'What you do may keep a smile on your customer's face, but how you do it will keep you on schedule and on budget-and that may make the customer's smile even brighter and longer lasting'. The first step, according to Rose, (2014) is to answer the question 'what is quality?

PMBOK guide, (2017) defines quality as the totality of characteristics of an entity that bear on its ability to satisfy stated or implied needs. It recognises the importance of customer satisfaction, prevention over-inspection, and management responsibility. Rose, (2014) defines quality as fitness for use and fitness for purpose. Quality includes features that meet customer needs. Quality includes freedom from failures, (Rose, 2014). These failures may be errors during production that require rework, or failures in the field after purchase that may result in warranty claims, customer dissatisfaction, or dire consequences to the user, (Rose, 2014). Rose (2014) further reasons that 'because an absence of failures means an absence of associated costs, it is reasonable to say that higher quality costs less'.

The project management institute defines quality as the degree to which a set of inherent characteristics fulfil requirements. This definition is taken directly from ISO 9000:2005, published by the International Organization for Standardization.

Nicholas and Steyn (2017), allude that the term quality implies that a product or deliverable is fit for the intended purpose. This can involve a wide range of criteria such as performance, safety, reliability, ease of handling, maintainability, logistical support, and no harmful environmental impacts. Beyond fitness, however, the customer will also consider a product's value for money and whether it is priced right for the intended purpose, [therefore] optimising only one aspect of a product – fitness for purpose, value for money, or strategic benefit to the organisation will not necessarily result in an optimal product, (Nicholas & Steyn, 2017).

Project quality management includes the processes for incorporating the organization's quality policy regarding planning, managing, and controlling project and product quality requirements to meet stakeholders' objectives, (PMBOK Guide, 2017). Project quality management is the process for ensuring that all project activities necessary to design, plan and implement a project are effective and efficient with respect to its purpose, objective, and performance, (PM4Dev, 2016). Project quality management also supports continuous process improvement activities as undertaken on behalf of the performing organization, (PMBOK Guide, 2017).

While project performance is generally evaluated in terms of schedule, cost and quality performance, guidelines for project quality management are lacking, (Steyn and Nicholas, 2008). Steyn and Nicholas (2017) have alluded that practitioners developing complex engineering systems employ several techniques to manage quality, but project management literature merely emphasizes quality management processes and provides few guidelines regarding appropriate techniques.

In the early 1950s project management was mainly concerned with scheduling and budgeting. It later drew knowledge from a variety of other disciplines and redefined it to include knowledge areas such as human resources (HR) management, risk management, procurement management as well as quality management, (Steyn and Nicholas, 2008). Quality management used to be a mere activity of sorting bad products from good products, the emphasis has since shifted to processes to prevent defects and failures. Steyn and Nicholas (2017) stated that project quality management comprises of three (3) elements being quality planning, quality assurance and quality control. They continue to say that quality planning should include decisions regarding actions that are required to meet quality requirements.

In the case of projects, quality planning involves decisions regarding:

a. Requirements that need to be met (as embodied in agreed specifications and standards) including benchmarking against other projects.
b. Actions required in the overall project plan to meet the required specifications and standards, including the techniques that would be used in quality assurance and quality control.

It is important to ensure that quality activities form a well-integrated part of the overall project plan, (Steyn and Nicholas, 2017).

2.2.1 The evolution of quality management and its contemporary application to projects

The concept of quality evolved over time. It evolved in progressive steps that responded to the needs and limitations of the times, (Rose, 2014). Prior to World War 1, quality was viewed predominantly as inspection to sort out the bad products from the good products, (Kerzner, 2003). Kerzner (2003) further alludes that during the past twenty (20) years, there has been a revolution in quality and improvements have occurred not only in product quality, but also in leadership quality and project management quality. Kerzner (2003) postulates that the push for higher levels of quality appears to be customer driven as customers are now demanding:

a. Higher performance requirements.

b. Faster product development.
c. Higher technology levels.
d. Materials and processes pushed to the limit.
e. Lower contractor profit margins.
f. Fewer defects/rejects.

Kerzner (2003) also posits that one of the factors that can affect quality is market expectations and the variables in market expectations include:

a. Saleability: the balance between quality and cost.
b. Producibility: the ability to produce the product with available technology and workers, at an acceptable cost.

2.2.2 The changing views of quality

During the past 20 years, there has been a revolution in quality [and] improvements have occurred not only in product quality, but also in leadership quality and project management quality, (Kerzner, 2003). Kerzner, (2003) further posits that the push for higher levels of quality appears to be customer driven. Customers are now demanding:

- Higher performance requirements
- Faster product development
- Higher technology levels
- Materials and processes pushed to the limit
- Lower contractor profit margins
- Fewer defects/rejects

Table 1: Changing views of quality. Source: Project management, a systems approach to planning, scheduling, and controlling, Kerzner, 2003.

Past	Present
Quality is the responsibility of blue-collar workers and direct labour employees working on the floor	Quality is everyone's responsibility including white-collar workers, indirect labour force and the overheads staff.
Quality defects should be hidden from the customers (and possibly management)	Quality defects should be highlighted and brought to the surface for corrective action.
Quality problems lead to blame, faulty justification**,** and excuses	Quality problems lead to cooperative solutions
Corrections to quality problems should be accomplished with minimum documentation	Documentation is essential for 'lessons learnt' so that mistakes are not repeated.
Increased quality will increase costs	Improved quality saves money and increases business
Quality is internally focused	Quality is customer focused
Quality will not occur without close supervision of people	People want to produce quality products
Quality occurs during project execution	Quality occurs at project initiation and must be planned for within the project

2.2.3 Project quality management processes

The PMBOK guide states that project quality management includes the processes and activities of the performing organisation that determine quality policies, objectives, and responsibilities so that the project will satisfy the needs for which it was undertaken. Steyn and Nicholas (2017) state that quality planning guides future quality activities whilst quality assurance performs the planned quality activities and ensures [that] the project utilizes the processes necessary to meet quality standards and end-item requirements. Quality control on the other hand ensures that quality assurance activities are performed according to quality plans and that requirements and standards are being met, (Nicholas and Steyn, 2017). According to Rose (2014), many approaches to quality management exist. The Juran trilogy describes three slightly different elements: quality planning, quality control, and quality improvement. In Juran's view, quality assurance is like quality control but performed by those not directly involved in producing the product [or third parties]. Juran also adds an essential element quality improvement, which the PMBOK guide does not include as a distinct process. Rose's (2014)

approach combines the best of these two views to include quality planning, quality assurance, quality control, and quality improvement. In Nicholas and Steyn's (2017) view, project quality control links quality planning and quality assurance to ensure that quality assurance occurs according to the quality plan. This is depicted in figure 2 below. Rose (2014) further alludes that project quality management is linked to organisational quality management in terms of processes and costs.

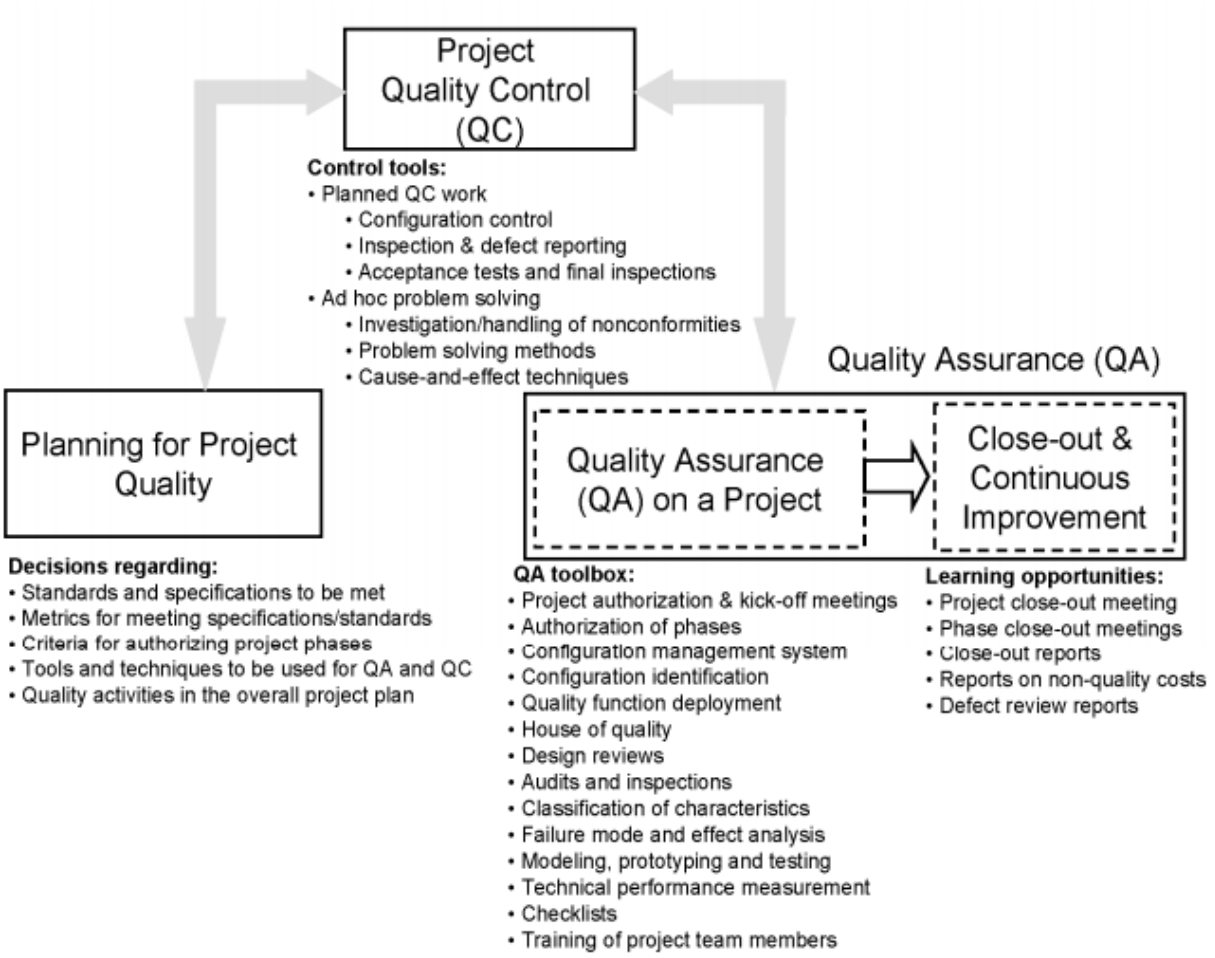

Figure 2: The project quality management processes. Source: Nicholas and Steyn, 2017

2.2.3a Quality planning

Quality planning is the process of identifying quality requirements and/or standards for the project and its deliverables and documenting how the project will demonstrate compliance with quality requirements, (PMBOK guide, 2017). Rose (2014) argues that quality planning is the foundation for quality being planned in at the inception of the project, not inspected in during the project execution as is the norm. Quality planning is identifying which quality standards are relevant to the project and determining how to satisfy quality standards, (International Journal of Innovative research in science, engineering and technology, 2014). Nicholas and Steyn (2008) state that quality planning should include decisions regarding actions required to meet quality requirements and the planned quality actions often entail the use of specific quality assurance (QA) and quality control (QC) techniques.

The QA and QC techniques therefore need to be further decided upon during the quality planning stage [and] involves decisions regarding:

a. Requirements that need to be met (as embodied in agreed specifications and standards), including benchmarking against other projects.
b. Actions required in the overall project plan to meet the required specifications and standards, including the tools and techniques that would be used in QA and QC.
c. Metrics to be used to determine whether the specifications and standards have been met.

Nicholas and Steyn, (2017) further allude that quality planning should provide confidence that everything necessary to ensure quality has been taken care of. It has two aspects:

a. Establishing quality management procedures and policies for the entire organisation.
b. Establishing a quality plan as part of the execution plan for [the] project.

Projects often employ quality standards that already exist such as the ISO 9001 standard [which] prescribes that an organization shall set procedures for:

a. The design and development stages.
b. The necessary reviews, verifications, and validations appropriate to each of the stages.
c. The responsibilities and authorities for the stages, (Nicholas and Steyn, 2017).

It is important to note that quality activities should form a well-integrated part of the overall project plan, (Nicholas and Steyn 2008). Another facet of quality planning is decisions on how the individual project under consideration could aid the continuous improvement of company-wide policies and procedures to enhance company-wide quality.

Project quality management plan

According to Nicholas and Steyn (2017) project quality management plan is an important component of the project execution plan [and] it addresses the quality management approach of the project, indicates the stakeholders involved and how the project would respond to any changes in customer needs. The quality management plan should address all relevant elements including how the project team will ensure that the quality requirements as stated in the specifications and standards would be met, (Nicholas and Steyn, 2017). This can typically include:

a. Any models/prototypes to be produced and tested, and associated test specifications, procedures, and reports.
b. Inspections, equipment required for inspections, calibration of equipment, and required reports.
c. Any required design reviews, the purpose of each review, people involved, and outputs required.

d. Audits.
e. Checklists.
f. Techniques that would be used, e.g., control charts.

The quality management plan can also indicate how non-conformances, customer complaints, and corrective actions would be handled [and] clearly indicate people responsible for each task and the roles and responsibilities of others involved, (Nicholas and Steyn, 2017). Rose, (2014) concludes that quality planning is important and has far reaching effects on project performance. He further alludes that in project performance, changes made early (during planning) are less expensive than changes made later (during implementation).

2.2.3b Quality Assurance

The PMBOK guide 6th edition (2017) states that quality assurance is about using project processes effectively [and] involves following and meeting standards to assure stakeholders that the final product will meet their needs, expectations, and requirements. The PMBOK guide 5th edition (2013) defines quality assurance as the process of auditing the quality requirements and the results from quality control measures to ensure that appropriate quality standards and operational definitions are used. Rose (2014) states that quality assurance can be a troublesome term because it has distinctly different meanings to different people. Quality control is performed by those directly responsible for producing a product [while] quality assurance is performed by people external to the production process who have a need to know about the quality of the product, (Rose, 2014). The third edition of the PMBOK guide defined quality assurance as the application of planned, systematic quality activities to ensure that the project will employ all processes needed to meet requirements.

ISO 9000 defines quality assurance as the part of quality management focused on providing confidence that quality requirements will be fulfilled.
Nicholas and Steyn (2017) define project quality assurance as the execution of the project quality management plan and aims to reduce the risks of not meeting the desired outcomes or performance requirements of set deliverables. They further allude that quality assurance covers activities done in a specific project to ensure that the requirements are being met and that the project is being executed according to the quality plan. Also covered by quality assurance are the activities that contribute to the continuous improvement of current and future projects and to the project management maturity of the organisation. Quality assurance is the planned and systematic activities implemented within quality system and demonstrated, as needed, to provide adequate confidence that an entity will fulfil

requirements for quality, (International Journal of Innovative research in science, engineering and technology, 2014)

2.2.3c Quality Control and Quality Improvement

Quality control is the ongoing process of monitoring and assessing work and taking corrective action to achieve the planned quality outcomes as stipulated in the requirements and specifications in the project quality plan, (Nicholas and Steyn, 2017). The 6th edition of the PMBOK Guide defines quality control as the process of monitoring and recording results of executing the quality management activities to assess performance and ensure the project outputs are complete, correct, and meet customer expectations. This is an action process in which the project team looks at results and determine necessary corrective action, (Rose, 2014). The key benefit of quality control is verifying that project deliverables and work meet the requirements specified by key stakeholders for final acceptance [and] the process determines if the project outputs do what they were intended to do, (PMBOK Guide, 2017).

According to Kenneth Rose in his 2014 Project quality management book, the monitoring of specific results serves several important purposes as outlined below:

a. Results may confirm that all is well. If results are within specifications, then the project team knows that performance is proceeding according to plan.
b. Results may provide the basis for corrective action. If results do not conform to specifications (some degree of variance is indicated), the project team knows that something has gone wrong or is going wrong [and] must take corrective action to fix the existing variance from the plan. This includes identifying the source of the variance and taking corrective action to prevent it from recurring.
c. Results provide feedback to the quality assurance process**.** Results obtained during quality control provide data that are examined during quality audits.

Quality control can be contrasted to scope verification: whereas scope verification refers to the acceptability of project deliverables by the customer, quality control refers to conformance to specifications as set by the contractor. Scope verification includes verifying the acceptability of specifications and standards, but quality control refers to verifying adherence to previously set specifications and standards, (Nicholas and Steyn, 2017). The quality control process includes inspections to verify that deliverables are meeting specifications, [as well as] acceptance tests before handover of deliverables to the customer, (Nicholas and Steyn, 2017)

Rose, (2014) states that the loop from quality control back to specifications is not the end of the quality journey, it goes back to quality improvement. Quality improvement is a deliberate process that uses objectives measurement and data. All quality improvement begins with data collection, (Rose, 2014). Rose, (2014) further alludes that quality improvement is not just a good idea to do but it is done for many practical reasons which demand that organizations continually improve their quality of products or services. Quality improvement is a matter of business survival, (Rose, 2014).

According to Rose (2014), there are multiple reasons for quality improvement such as:

a. To improve products or reduce deficiencies [to] improve customer satisfaction, improve reputation, and increase competitiveness.
b. Better processes may result in more efficient use of time, less waste or fewer defects.
c. Dynamic customer needs and requirements demand continuous improvement to avoid being overtaken by competitors with better new ideas.
d. Quality improvement may reduce costs which can in turn increase competitiveness through lower prices.
e. New technologies and the pace of technological development require change and enable quality improvement.

2.3 Quality Management System (QMS)

This section looks at the overview of QMS so that it can be understood and used to evaluate the maturity level of the QMS system in the organisation under review as per research objectives.

The 6th edition of the PMBOK guide defines quality management system as the organizational framework whose structure provides the policies, processes, procedures, and resources required to implement the quality management plan. The typical project quality management plan should be compatible with the organization's quality management system, (PMBOK Guide,2017). A quality management system is how quality management practices are made an integral part of an organization, (Nanda 2007). Nanda continues to elaborate further that a QMS has a structure, a defined scope, responsibilities, necessary content [in terms of defined processes and supporting QMS documentation], and the required resources to accomplish quality planning, quality control, quality assurance and continuous quality improvement activities. A quality management system consists of the organizational structure, processes, procedures, and resources needed to implement quality management, (Nanda, 2007).

As summarized by Carey and Hilton (2018)

> 'a quality management system is an integrated set of activities to establish and control work processes, manage resources, conduct evaluations, and continually improve. It covers a broader range of activities than QC and QA by including both technical and management requirements. A QMS provides the tools to increase the consistency of processes, services, and products and to reduce expensive mistakes. Working in a QMS enhances the likelihood of a successful regulatory inspection.'

According to Kerzner, (2003), there are six QMS concepts that should exist to support each project. They include:

a. Quality policy.
b. Quality objectives.
c. Quality assurance.
d. Quality control.
e. Quality audit.
f. Quality program plan.

Ideally, these six concepts should be embedded within the corporate culture, (Kerzner, 2003). Kerzner (2003) further elaborates these concepts as follows:

2.3.1 Quality Policy

The quality policy is a document that is typically created by quality experts and fully supported by top management, (Kerzner, 2003). Kerzner further says that the policy should state the quality objectives, the level of quality acceptable to the organization, and the responsibility of the organization's members for executing the policy and ensuring quality, [including] statements by top management pledging [their] support to the policy. The quality policy is instrumental in creating the organization's reputation and quality image, (Kerzner, 2003). In Kerzner's view, the implementation of the quality policy is the responsibility of top management, and he believes that a good quality policy will:

a. Be a statement of principles stating what, not how.
b. Promote consistency throughout the organization and across projects.
c. Provide an explanation to outsiders of how the organization views quality.
d. Provide specific guidelines for important quality matters.
e. Provide provisions for changing/updating the policy.

2.3.2 Quality Objectives

Quality objectives are a part of an organization's quality policy and consist of specific objectives and the time frame for completing them. Good quality objectives should:

a. Be obtainable.
b. Define specific goals.
c. Be understandable.
d. State specific deadlines.

2.3.3 Quality assurance

Quality assurance is the collective term for the formal activities and managerial processes that attempt to ensure that products and services meet the required quality level. Quality assurance also includes efforts external to these processes that provide information for improving the internal processes. It is the quality assurance function that attempts to ensure that the project scope, cost, and time functions are fully integrated. The project manager needs to establish the administrative processes and procedures necessary to ensure and, often, prove that the scope statement conforms to the actual requirements of the customer. The project manager must work with his team to determine which processes they will use to ensure that all stakeholders have confidence that the quality activities will be properly performed. All relevant legal and regulatory requirements must also be met.

A good quality assurance system will:

a. Identify objectives and standards.
b. Be multifunctional and prevention oriented.
c. Plan for collection and use of data in a cycle of continuous improvement.
d. Plan for the establishment and maintenance of performance measures.
e. Include quality audits.

2.3.4 Quality Audit

A quality audit is an independent evaluation performed by qualified personnel that ensures that the project is conforming to the project's quality requirements and is following the established quality procedures and policies.

A good quality audit will ensure that:

a. The planned quality for the project will be met.
b. The products are safe and fit for use.

c. All pertinent laws and regulations are followed.
d. Data collection and distribution systems are accurate and adequate.
e. Proper corrective action is taken when required.
f. Improvement opportunities are identified.

2.3.5 Quality Plan

The quality plan is created by the project manager and project team members by breaking down the project objectives into a work breakdown structure. Using a treelike diagramming technique, the project activities are broken down into lower-level activities until specific quality actions can be identified. The project manager then ensures that these actions are documented and implemented in a sequence that will meet the customer's requirements and expectations. This enables the project manager to assure the customer that he has a road map to delivering a quality product or service and therefore will satisfy the customer's needs.

A good quality plan will:

a. Identify all the organization's external and internal customers.
b. Cause the design of a process that produces the features desired by the customer.
c. Bring in suppliers early in the process.
d. Cause the organization to be responsive to changing customer needs.
e. Prove that the process is working and that quality goals are being met.

2.4 Conceptual Framework

Miles and Huberman, (1994) defined a conceptual framework as a visual or written product, one that "explains, either graphically or in narrative form, the main things to be studied, the key factors, concepts, or variables, and the presumed relationships among them. The research study adopted a conceptual framework as shown in figure 3 below with a dependent variable, independent variables, and intervening variables.

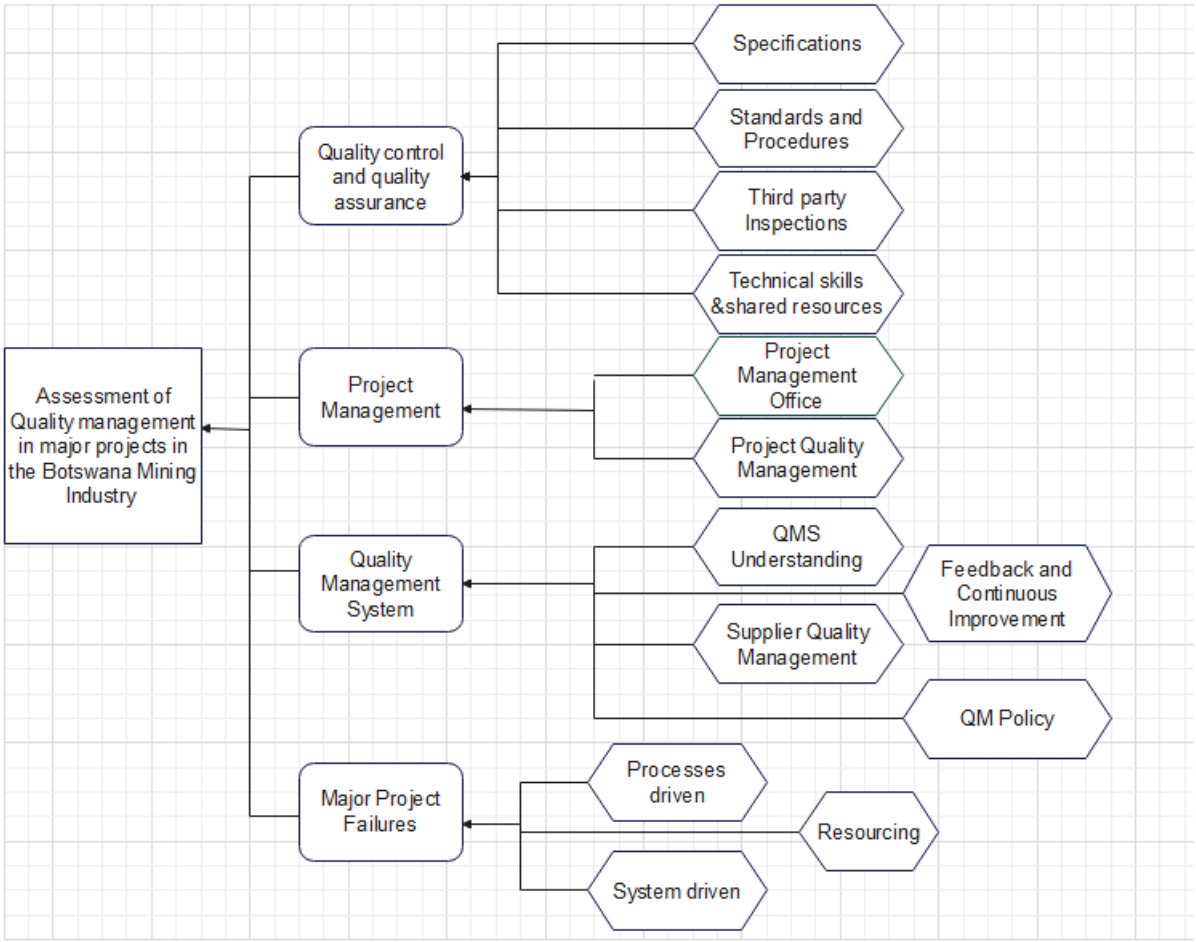

Figure 3: Conceptual framework adopted for the research.

2.5 QMS Maturity

According to Baskarada et al, (2007), the idea of Quality Management Maturity came with Phillip Crosby in 1979, (who) proposed five (5) levels of organisational Quality Management Maturity which represent an evolutionary path of increasingly structured and methodically more mature quality management processes. Baskarada et al further posit that each level is dependent on several maturity indicators, which in turn depend on several criteria.

Table 4: Table showing different QMS maturity levels with their indicators and criteria

Maturity Level	Maturity Indicator	Criteria
Level 5 OPTIMISING	Continuous improvement	1. QMS in corporate balanced score card 2. PDCA cycle for QMS improvement
Level 4 MANAGED	1. Single point of truth 2. QMS governance	1. Information integration 2. Data warehousing 3. QMS accountability 4. QMS risk management and impact assessment
Level 3 MEASURING	1. Information management 2. QM roles and responsibilities 3. Security Management	1. Information Product Supply Management 2. Information Product Templates 3. Information Profiling & Enrichment
Level 2 REACTIVE	1. Information modelling management 2. Information storage management 3. Access control management	1. Conceptual information modelling 2. Physical information modelling 3. Backup and recovery 4. Redundant storage management 5. Authentication 6. Audit trail
Level 1 CHAOTIC	No maturity indicators	

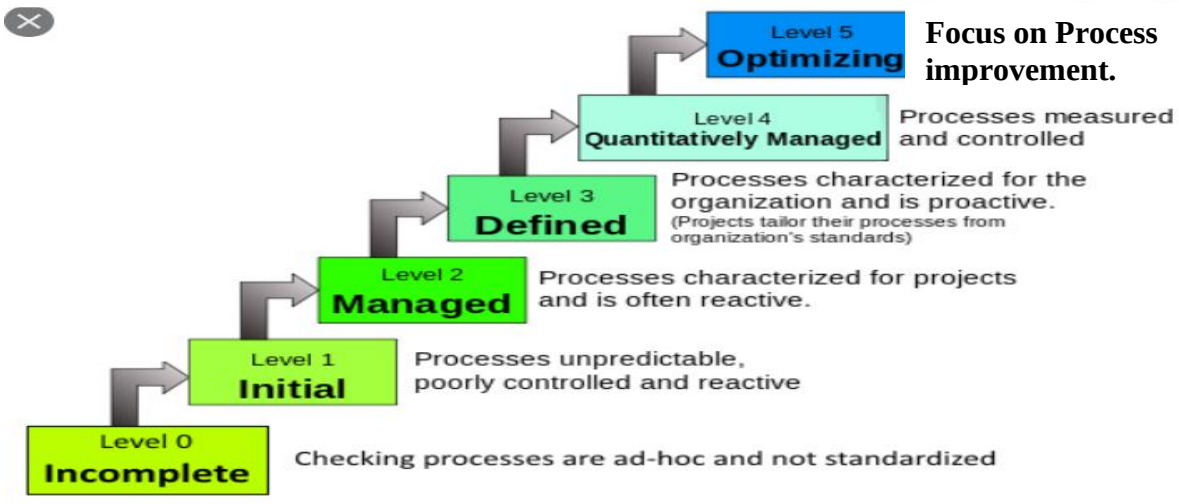

Figure 4: Depiction of different QMS maturity levels

CHAPTER 3: RESEARCH METHODOLOGY

3.1. Research Design

A research design is the logic that links the empirical data to be collected, [and the conclusions to be drawn] to the initial question of study, (Yin, 2009). A research design can be considered as a blueprint for the research dealing with at least four (4) problems: what questions to study, what data are relevant, what data to collect and how to analyse the results.

In this case the problem being researched was to evaluate status of adoption and implementation of quality management systems (QMS) in Botswana Debswana Diamond company in relation to major projects.

To meet the objectives of the study, a qualitative approach was chosen. This study used results from archival research i.e. a review of company documents and reports from the repository to formulate a hypothesis, then ran a survey to gauge the maturity level of the QMS system and implementation thereof. Results from the survey and archival research were then triangulated and converged to corroborate the research question and conclude the findings. The research design followed the framework depicted below.

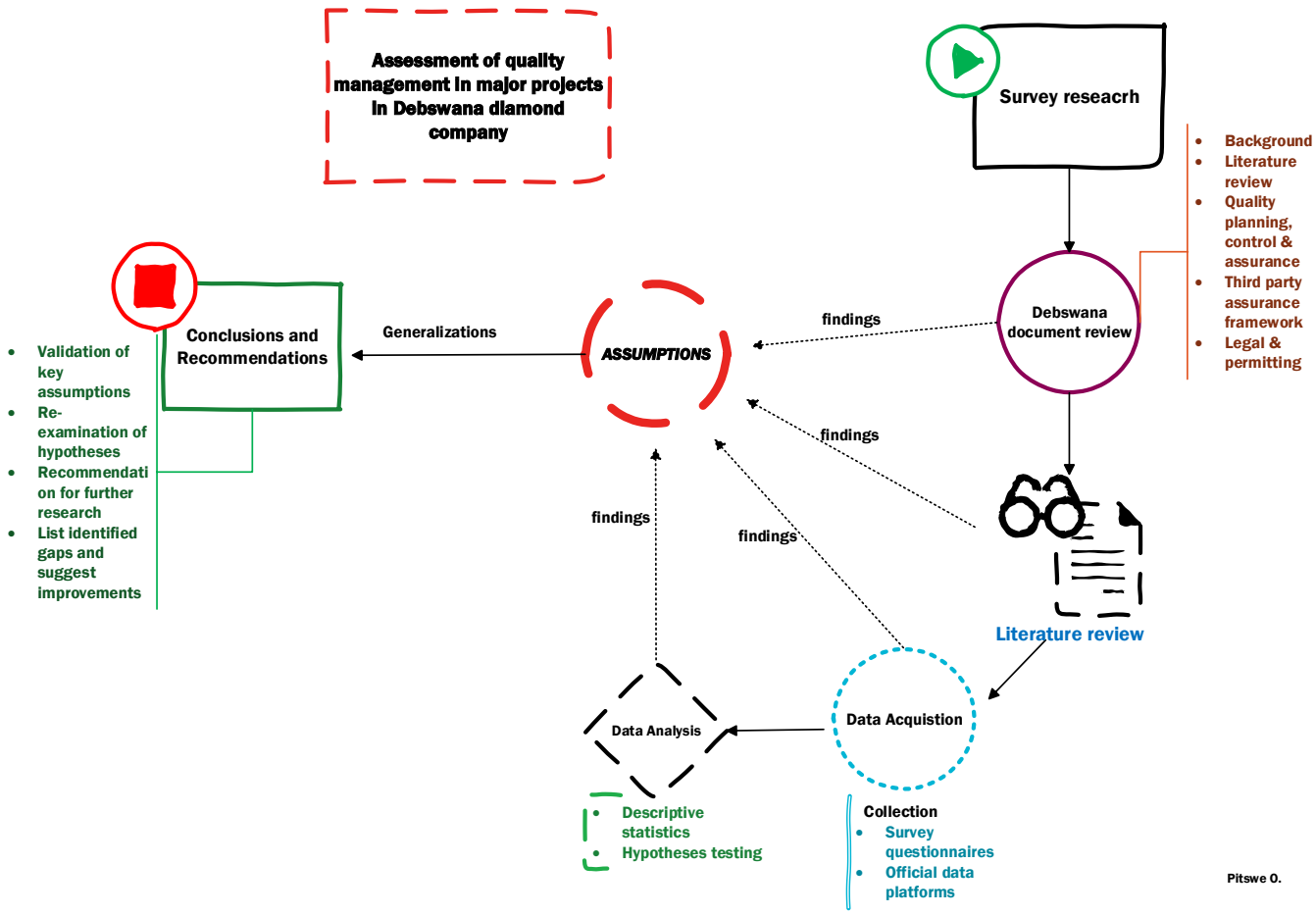

Figure 5: Framework showing the research methodology that was adopted.

The research philosophy adopted for this study is interpretivism which according to Dudovskiy (2018) involves the researcher to interpret elements of the study and integrates human interest into the study. The research for interpretivism is value bound, and the researcher is part of what is being researched i.e., an employee of the company being researched. This therefore means that, as a criticism of interpretivism, bias is automatically inherent.

To overcome this bias, survey as a qualitative research instrument was used to collect opinions and perceptions of the people and the data was quantitatively analyzed and triangulated with findings from the archival research from the company document review to ensure validity and reliability.

3.2 Research Instruments

Data collection is a process of collecting information from the relevant sources to find answers to the research problem, test the hypothesis and evaluate the outcomes, (Dudovskiy, 2018).

Creswell (1999) have explained the triangulation method as a type of methodology in which different but complementary data is collected on the same topic to offer different perspectives, thus aiding the researcher in understanding their research area better. This is used to ensure validity and reliability. For this study, the triangulation design with convergence model was used. According to Creswell (1999) the convergence model/variant represents the traditional model of mixed methods triangulation design [whereby] the researcher collects and analyses quantitative and qualitative data separately [and concurrently] on the same phenomenon and then the different results are converged during their interpretation. Creswell (1999) further alludes that researchers use this model when they want to compare results or to validate, confirm or corroborate quantitative results with qualitative findings.

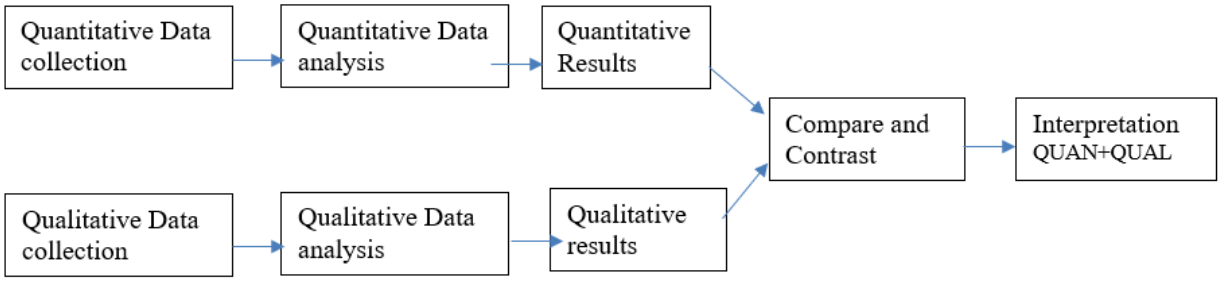

Figure 6: Flow diagram showing the triangulation mixed methods.

3.3.1 Survey

A survey research instrument was used for this study to evaluate the maturity level of quality management system in Debswana projects. Data collected through the survey was primary data as it was collected and compiled by the researcher.

The survey questionnaire (quantitative data collection) was focused on Debswana Diamond Company. Close ended questions were developed and sent out to respondents to solicit their answers which were later analysed to evaluate the effectiveness of the quality management system in Debswana projects and the maturity level thereof. The questionnaire was further used to determine the top causes/reasons for projects failure in Debswana.

A survey instrument was formulated using close-ended questions in a Likert scale format and sent to the respondents via email. The response options were from zero (0) to five (5). The zero answer was “I don’t know” which gave respondents a chance to not respond to something which they did not have knowledge of. This tool is preferred as it can easily reach many respondents in a short time and is cost economical. It must be noted, however, that online survey has its limitation such as the

rigidity of the questions and the inability of the researcher to probe beyond given answers. Therefore, it was important for the researcher to design questions that are as exhaustive as practically possible to try and eliminate the limitation of rigidity.

Pre-test and pilot testing

The pre-test implementation is to evaluate the functioning of the question with a small group of people before applying it to the larger research sample, (Gurbus, 2017). For this research, the questionnaire was developed and pre-tested so that it can be revised where necessary. This helped ensure that potential problems are identified and dealt with and thus improve the reliability of the research, (Field, 2015). Two types of persons were involved in the pre-test: work colleagues (project engineers and project managers) and an independent research expert from a local university, Professor O.S Motsamai from the University of Botswana. The aim of the pre-test was not to make any generalizations, but rather, to determine whether there are any unpredictable problems, language clarity, structure, and format (Gurbus, 2017).

The questionnaire was sent out together with a letter of consent and the respondents were encouraged to participate voluntarily with an option to withdraw their participation at any time they feel like.

3.3.2 Document Analysis (Archival Research)

To further complement the survey method, archival research was also conducted through historical archive analysis in the quality management system for Debswana, quality standards and procedures as well as the lessons learnt reports (LLRs) and project retrospect reports which are normally carried out and documented at the end of every critical project. This type of data collected from archival research is secondary because it was not compiled by the researcher. It should be noted that this is also confidential and sensitive information hence specific names and details of the reviewed projects were not disclosed in this report. In the document analysis, the researcher looked at the most commonly appearing causes of project failure and tallied them for each project under review. These were later compared to the common ones from the survey results as a way of corroborating them.

3.4 Sampling

The sample characteristics included all genders, project managers, end users, project engineers, project cost accountants, project controllers and project portfolio managers in Debswana project management operation. One of the weakest points of survey research is its low rate of response with

an average range of 15-35%, (Gurbus, 2017). Debswana projects teams across all operations, (Orapa, Jwaneng and the Corporate center), has a total of 900 employees.

Using Slovin's (1960) formula (Kothari,2004):
n=N /(1+Ne2) where n= sample size, N = Population and e =error of sampling.
With a confidence level of 95%, response rate and an error of sampling of 5% we get a sample size of 277.

N=900/(1+900*0.052)=276.9=277
The target was to send out at least 277 survey questionnaires to respondents with a target response rate of 35% which is the maximum average response rate for survey research (Gurbus, 2017). Of the 277 questionnaires sent out, only 88 managed to respond. This gives a response rate of 32% which falls within the average response rate for survey research as determined by Gurbus (2017).

3.5 Data Analysis

LeCompte and Schensul (1999) define analysis as the process a researcher uses to reduce data to a story/information and its interpretation. Data analysis is the process of reducing large amounts of collected data to make sense of them, (Kawulich, 2004). Patton (1987) indicates that three things occur during analysis: data are organized, data are reduced through summarization and categorization, and patterns and themes in the data are identified and linked. Data analysis comprises interpretation and critical analysis of research findings, (Patton, 1987). Depending on the type of data that you have collected, methods of data analysis can be divided into two categories - qualitative data analysis and quantitative data analysis, (Dudovskiy, 2018). According to Denzin (1970) as cited by Rugg (2010), triangulation is the use of multiple methods to study a situation or phenomenon where one method is used to corroborate results of the other. The intention is to decrease the deficiencies and biases that come from any single method. In other words, the strengths of one method may compensate for the weaknesses of another [as well as] to enhance, augment and clarify the results of another method.

Rugg (2010) further posits that Denzin (1970) proposed the following reasons for triangulation of research methods:

a. Enriching: The outputs of different informal and formal instruments add value to each other by explaining different aspects of an issue.

b. Refuting: Where one set of options disproves a hypothesis generated by another set of options.
c. Confirming: Where one set of options confirms a hypothesis generated by another set of options
d. Explaining: Where one set of options sheds light on unexpected findings derived from another set of options.

For this study, both qualitative and quantitative data analysis were employed for analysis of archival research data and survey research data respectively.

Having used the two research methods, the researcher was able to gain different insights and perspectives of the research outcomes. Archival research provided secondary historic and current data, giving insights of the QMS system in Debswana projects as well as the most common causes of project failures in the company's major capital projects whilst survey research provided insights on how individual employees viewed the implementation and operationalization of the QMS system and what they think are the major causes of project failure in Debswana based on their experience and interactions with the projects department.

After the questionnaire was pre-tested, a pilot study was conducted to validate the research instrument. Statistical Package for the Social Science (SPSS) was used to analyse the collected data. The statistical results cover demographics data in the form of bar graphs and frequency distribution of the constructs. It also covers descriptive analysis and correlation analysis.

3.6 Validity of the research instrument

In quantitative studies, rigour is determined through an evaluation of validity and reliability of the tools or instruments used in the study (Heale and Twycross, 2015). Validation and review of the survey questionnaire was sought from at least three research experts, (both locally and internationally), to review and validate the questionnaires before the questionnaires were sent out. The validity of the questionnaire was also tested through pre-test method through a small sample group.

3.7 Reliability of the research instrument

Reliability refers to the consistency with which a survey questionnaire measures an attribute, (Baumgarten, 2010). In this research, the Cronbach's α was used to evaluate the reliability (internal consistency of all statements in the questionnaire). An alpha coefficient of 70% is proposed for this research.

3.8 Ethical Issues/Clearance

Ethics clearance was applied for and granted. Ethical issues were addressed in the following manner when carrying out the study:

f. Participation by respondents was voluntary.
g. Interview questions did not contain any offensive, discriminatory or any unacceptable language.
h. Privacy and anonymity of respondents was highly maintained.
i. The works of other authors that were used in any part of the study have been acknowledged and referenced.
j. The author maintained high levels of objectivity in all discussions and analyses.

The ethics clearance number from the school is **MIAEC 101/20.**

CHAPTER 4: RESULTS AND DATA ANALYSIS

The results of the research study are discussed in relation to the critical research question (CRQ) and its associated objectives as outlined in section 1.4 of this report which are reiterated below.

CRQ: What is the status of the adoption and implementation of quality management systems (QMS) in Botswana mining companies in relation to major projects.
The research objectives are as follows:

a. Determine the major causes of project failures related to quality management in Botswana Mining Industry.
b. Investigate the level of adoption and implementation of the quality management system (QMS) in projects in Botswana Mining industry.
c. Evaluate the effectiveness of quality management systems and processes in Botswana Mining Industry and identify gaps for improvement.

The researcher being an employee of the company being researched is exposed to the project management office and other major projects, therefore it was prudent to adopt the methodological triangulation strategy for minimization of bias. To achieve this, archival research results were corroborated by survey research results. The results were obtained from the two research strategies as outlined in the research methodology section of this report.

a. Archival Research: Review of project close out reports and Project Retrospective reports, (lessons learnt reports).
b. Survey research: Project Management office employees, engineers, end users and general employees.

All the two research methods provided different perspectives to the overall outcome of the research results. The archival research results provided insights into the historical and current context of adoption and implementation of QMS and its maturity level in the company while survey research results provided insights into how the employees perceive the adoption and implementation of the QMS, its practical application and operationalization based on their experience.

4.1 Archival research results

One of the project management processes in Debswana is to have a fully facilitated retrospect session at the end of every major project to document what went well and what went wrong so that learnings can be derived for future improvements. The ultimate deliverable of this kind of session is the "lessons learnt report' or LLR. The project retrospect session is a facilitated session that is normally outsourced to an independent third party to avoid bias and partiality. The session reviews all the good things that were realized in the project from inception through execution and all the way to commissioning and handover. This will cover the entire project life cycle and document all the positives for each stage. These are themed 'what went well'. The positive outcomes of the retrospect will then be further expanded for continuous improvement to identify what could have been done more to make them even more exceptional, and these would be mapped onto future or ongoing projects as learnings and continuous improvement activities. On the negative side, the retrospect session will investigate what went wrong. All negative aspects of the project from notable delays, reworks, cost overruns, schedule over runs, natural disasters, project timing and all others will be noted. The session will then investigate what could have been done better to prevent those negatives from happening, and what could be done in the future to avoid them. These learnings will also be shared with current and future projects as red flags to watch out for and avoid. The final report (lessons learnt report or LLR) will then be documented and filed into the project repository via the company portal and is accessible to all Debswana employees who have access to the company intranet. Part of 'what went wrong' are the actual causes of project failure.

Reports from 9 projects including major construction projects, ICT projects, technical investigations, expansion projects, and life of mine extension projects were selected and their LLR reports were studied to identify the major causes of project failure or what went wrong in the projects. The project names will not be mentioned in this study for confidentiality and ethics compliance purposes. These were further used to triangulate the survey research results and corroborate them to remove bias.
The results from the archival research are summarized below on table 34, and for each project, if any of the common causes of project failures identified from the literature was also listed in the project LLR then it was tallied out.

Table 2: Table showing causes of project failure and the frequency of their appearance on different project LLRs

Causes of project failures identified from literature review	**Projects under review**								
	1	2	3	4	5	6	7	8	9
Lack of sponsor/end user support/buy in	x				x				
Unclear strategic direction by management	x	x							
Inexperienced project team	x	x			x				x
Lack of stakeholder involvement and/or participation	x	x			x	x			x
Lack of documented requirements and/or success criteria	x								
Low morale of project team					x				
Shared resources and subject matter experts tend to get overstretched between projects and they end up neglecting quality assurance	x	x	x	x		x			x
Poor resourcing of projects especially on the quality management department	x			x			x		
Outdated technical specifications and quality management standards.								x	
Project milestones not met on schedule	x				x				
Poor stakeholder management and customer quality expectations	x	x	x		x		x	x	
Unclear statements of expected outcomes	x			x		x		x	
Undefined roles and responsibilities	x			x		x			x

(Source: Author)

A quantitative analysis was carried out by tallying the frequency of the project failure causes on a bar graph to get a clear graphical representation of the most frequently appearing causes to triangulate them against the survey research results and eliminate bias.

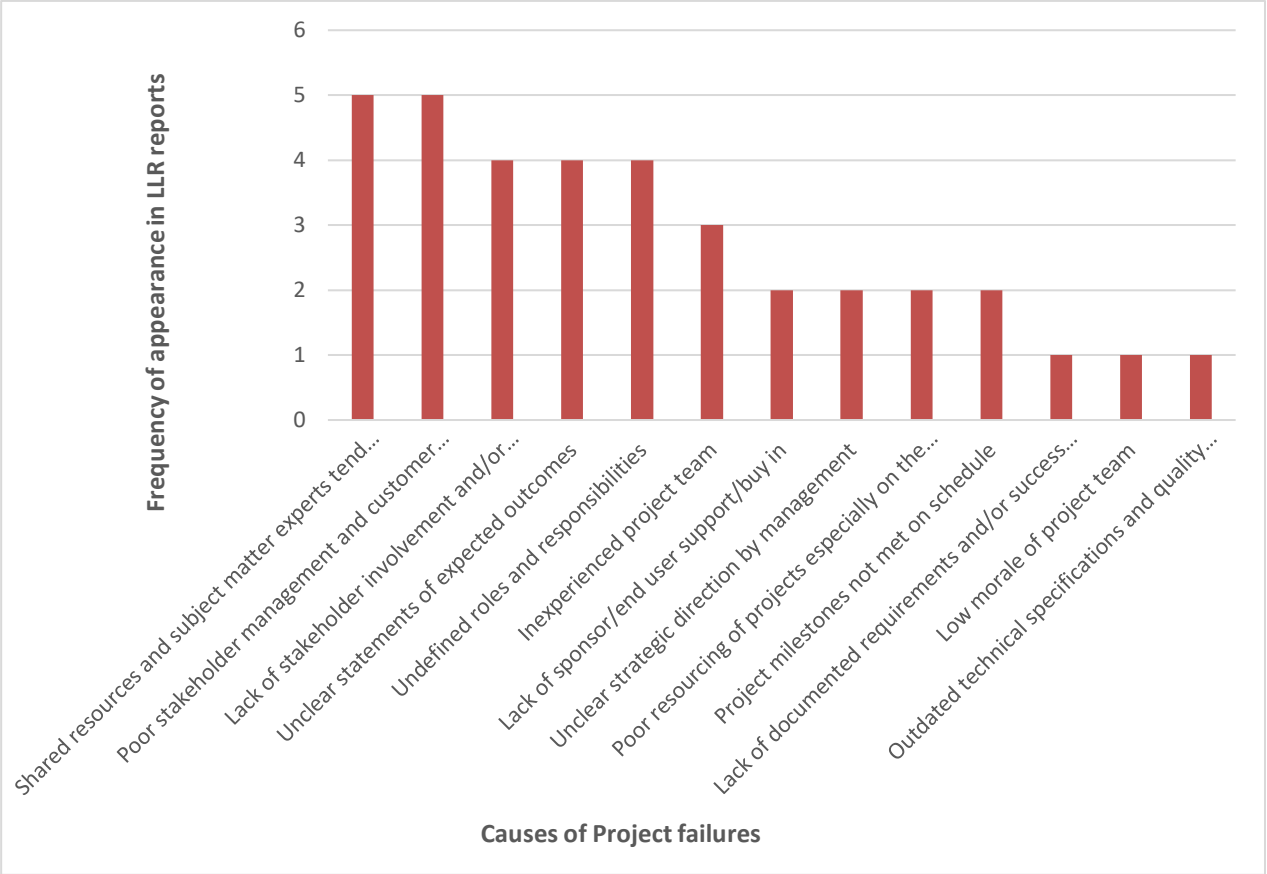

Figure 6: Bar graph showing the major causes of project failure and their frequency of appearance in different LLRs.

Over and above the major causes of project failure identified during the research process, two unexpected findings also emerged, one being the failure to identify critical interdependencies which were realized to have a big impact on the project success if not managed properly. This means individual capabilities required from external sources for the successful delivery of the project, which by extension affects the overall success of the project and represent a subset of the project risks, (Project Management Institute). The second unexpected finding was the lack of a controlled site instruction (SI) template for issuing site instructions during execution phase. The lack of an SI was found to lead to uncontrolled scope creeps emanating from instructions being issues haphazardly without consideration for additional scope and additional unplanned costs. This has been proven to cause projects to fail by failing to meet the required completion date from scope creeps and failing to meet budget requirements.

4.2 Survey Research results

The results of the research were discussed in relation to each construct/thematic idea which were derived out of the following three research objectives:

a. Evaluate the effectiveness of quality management systems and processes in Botswana Mining Industry and identify gaps for improvement.
b. Investigate the level of adoption and implementation of the quality management system (QMS) in projects in Botswana Mining industry.
c. Determine the major causes of project failures related to quality management in Botswana Mining Industry.

Different constructs were deduced which were meant to address the three (3) research objectives, and the different survey questions were formulated around each construct. This was done to arrive at the research aim of assessing the maturity level of the quality management system in Debswana projects. Results to each question are displayed below in the form of general statistics showing the modal answer to each question, frequency tables, and bar graphs.

4.2.1 Demographics

The distributions show that there were more male respondents (86%) than there were females (14%) as shown in figure 6 below. Most respondents (62%) were aged between 36-45 years, followed by 46-60 at 24% and lastly the young ones at 14% in the 20-35 age bracket. These demographics are shown in figure 7 below. Majority of the respondents are under the Debswana Corporate Centre operation, employed by Debswana and working in the Projects department. However, these demographics does not influence the outcomes in any way significant, except the respondents' area of employment (Debswana corporate centre) which had a lot of respondents working in the Projects department and have had relevant direct experience on the major engineering projects. This has shown also on the survey questions dealing with the existence of a QMS system being more prominent on this group because project management is their core business and therefore, they understand all the requisite processes thereof.

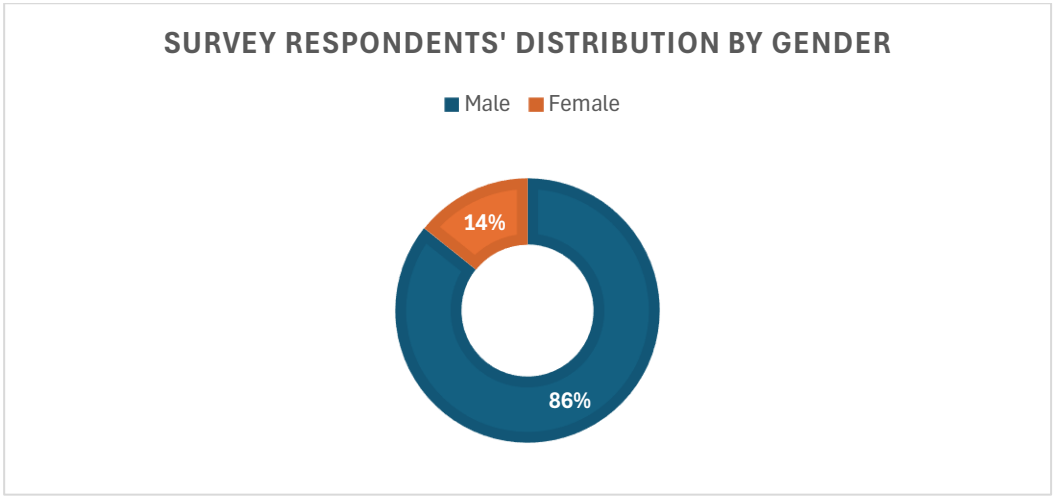

Figure 8: distribution of survey respondents by gender.

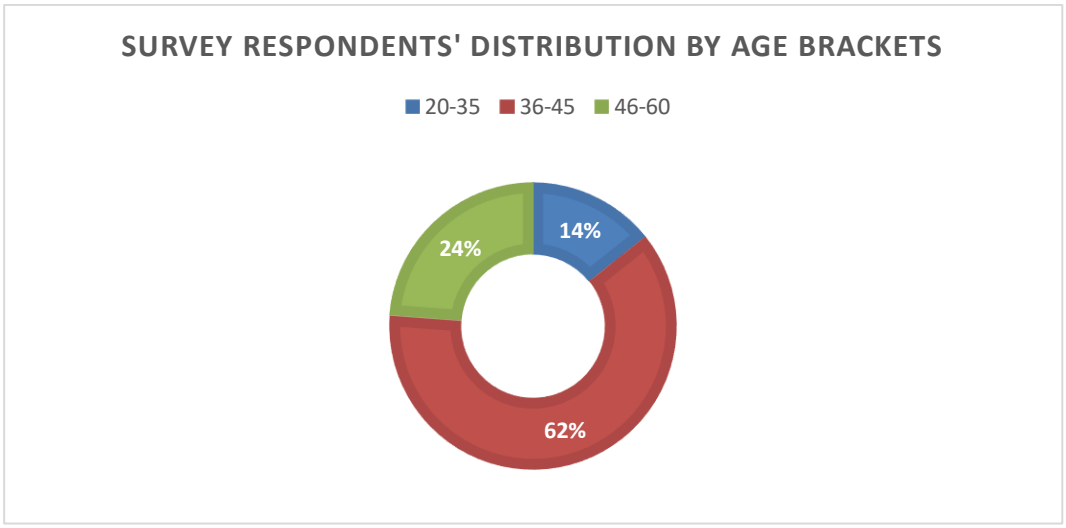

Figure 9: distribution of survey respondents by age brackets.

Construct/thematic idea 1: QMS understanding.

This thematic idea had five (5) questions/statements that were used to gauge the respondents' general understanding of a quality management system and the requirements for the successful implementation thereof. Establishing understanding first is critical as it will assure the researcher that people responded to a phenomenon that they understood and therefore their responses were bound to give a representative conclusion. Furthermore, it was aimed at gauging the confidence level of the respondents regarding the development and effectiveness of the Debswana QMS framework which should be anchored around a quality policy at benchmark.

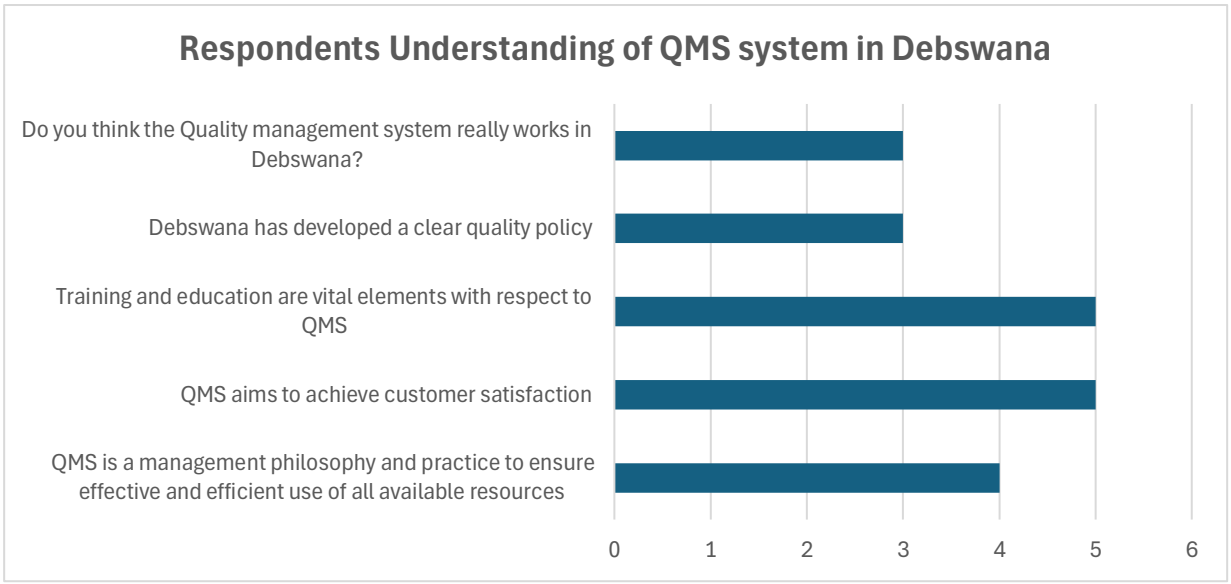

Figure 10: bar graph showing the modal responses for general understanding of QMS system in Debswana.

The responses as seen in figure 8 above demonstrate that the respondents have a clear understanding of what QMS is and what it aims to achieve especially in terms of customer satisfaction. They also strongly feel that training and education are vital elements with respect to QMS. They strongly agree to the notion that quality can assist the company to achieve customer satisfaction whilst ensuring effective and efficient use of all resources available. However, majority of the respondents preferred to remain neutral on whether the QMS policy is developed and if it really works as demonstrated by the first two questions. From these results, it was deduced that there is a clear understanding of the requirements of a QMS system from the respondents which gave assurance that the rest of the survey questionnaire will be responded to properly because they understood the basic requirements and objectives of a Quality Management System.

Construct/thematic idea 2: Quality management, Quality Control and Quality Assurance

This construct/thematic idea had six (6) statements/questions aimed at gauging the level of quality management, feedback from learnings and continuous improvement within the project's portfolio. It

also intended to determine from the respondents, the existence/occurrence of problems related to quality within major projects in Debswana.

Figure 11: Bar graph showing the existence of Quality control, quality assurance and quality management.

In summary, from the modal answers to the questions as shown in figure 9 above, it is evident that the company takes feedback from customers on issues of quality management as it is shown in table 10 above that most of the respondents agree to the statements. There are sentiments that the company does practice continuous improvement on all services and its processes, however there are still quality associated problems in major projects. This might have a link to the fact that respondents chose to remain neutral on the question of non-existence of a quality improvement coordinating body. The non-existence of this body means that feedback for quality improvement issues is all over the show and there is no central point of focus where all issues related to quality can be addressed and tracked until closure. Hence the reason why there are still problems related to quality yet there being feedback and efforts of continuous improvement.

Supplier quality management is one of the critical success factors for implementation of a quality management system. This includes supplier selection and listing, conducting supplier quality audits,

supplier facilities inspection. The respondents agree that indeed the company works closely with suppliers towards long term partnerships and that procedures allow for inspections and gate releases for critical equipment under design, fabrication, or repairs. This confirms that indeed the aspect of quality control is being practised by the company.

Construct/thematic idea 3: QMS adoption and operationalisation.

This construct/thematic idea was a yard stick test of the level of operationalisation of the quality management system Debswana has gone down to. This is particularly important as a critical success factor for the QMS implementation because the teams on the ground are the executers and if they are not brought on board or if they lack buy-in to the QMS then it is likely to fail. This checks the understanding of the QMS requirements by employees at all levels, gauges how empowered they are to make suggestions and contributions and if contractors are held accountable for poor quality work.

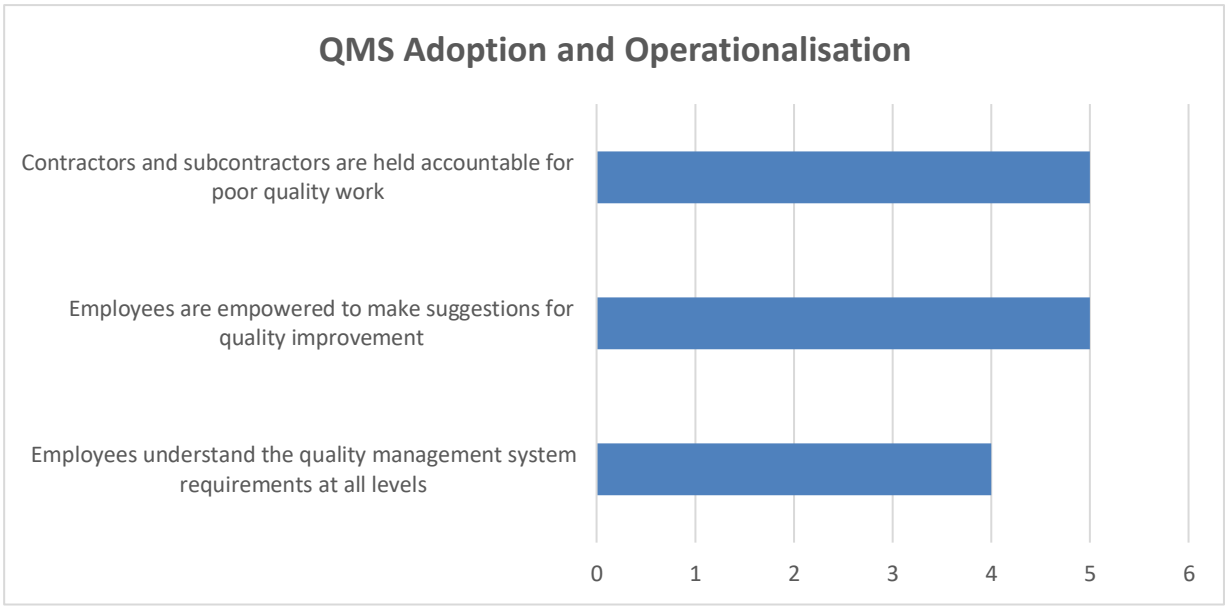

Figure 12: Bar graph showing the level of QMS adoption and operationalisation in Debswana.

With regards to the QMS operationalisation construct, most respondents seem not to be sure if employees understand the quality management system requirements at all levels, but largely agree that employees are empowered to make suggestions for quality improvement and agree that contractors and subcontractors are held accountable for poor quality work. This can then inform a conclusion that the level of operationalisation of the QM system is satisfactory. A gap was identified around the understanding of QM system requirements by lower-level employees which provides a

need for further investigation and coming up with recommendations of corrective measures to address the gap.

The last research question was to determine the major causes of project failure related to quality management in Debswana. A list was populated from the common causes of project failure as well as from those identified in lessons learnt reports and project retrospect's from the archival research. These formed part of the survey questions and respondents were requested to agree or disagree with them. Then their frequencies were graphed against each other to determine the top causes of project failures as depicted in the bar graph figure 31 below.

	Lack of input from critical stakeholders like end users and operations teams	Poor implementation of the quality management system and policy	Poor stakeholder management and customer quality expectations	Shared resources and subject matter experts tend to get overstretched between projects and they end up neglecting quality assurance	No budget set aside for quality management activities	Lack of stakeholder involvement and/or participation	Lack of quality engineers in the project structure	Inexperienced project team	Planning for quality is not done during the project initiation stages	Unclear statements of expected outcomes
Neutral	0	0	0	1	2	6	0	2	7	5
NO	0	1	0	1	0	0	6	9	6	10
YES	88	87	87	86	86	82	82	77	77	73

Figure 13: frequency table showing the most common causes of project failure and the distribution of responses.

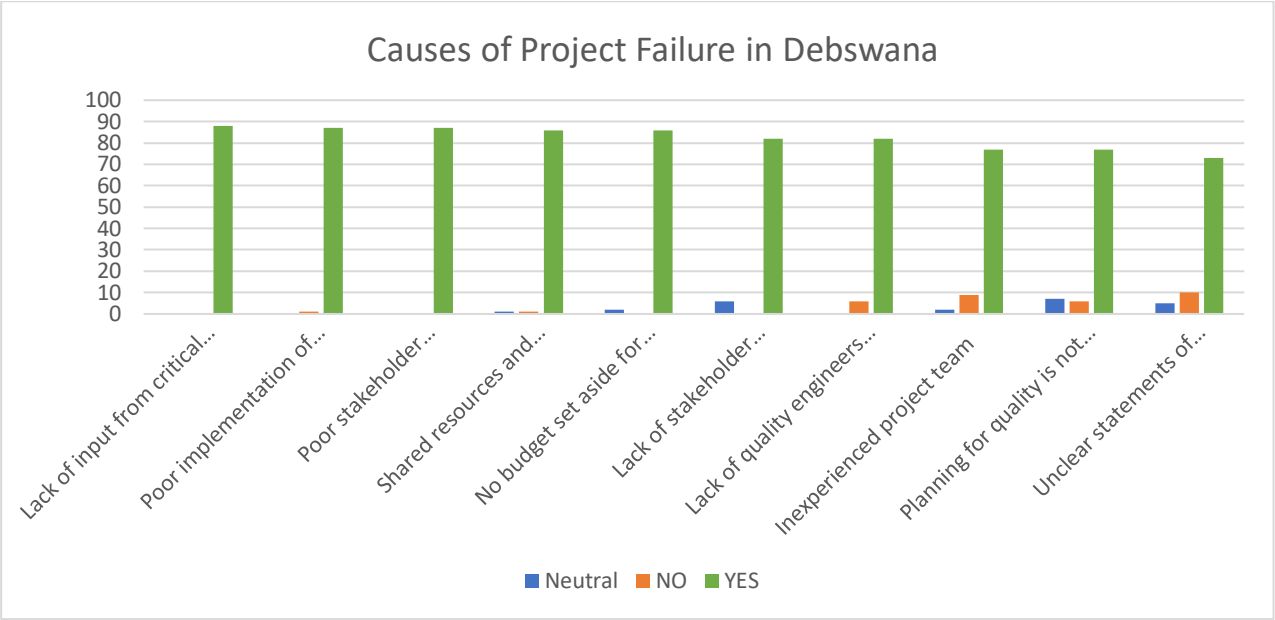

Figure 14: Bar graph showing the ranking of the causes of project failure to determine the top 5 causes of project failure.

4.3 Triangulation of results

As indicated earlier in the research methods section, the mixed method was used, the results of the two methods were triangulated to corroborate or confirm the findings. Creswell (1999) have explained the triangulation mixed method as a type of methodology in which different but complementary data is collected on the same topic to offer different perspectives, thus aiding the researcher in understanding their research area better. The triangulation was achieved by tallying corresponding causes from both research methods, i.e. if an identified cause of project failure appears both on archival research findings and survey research findings then the two are connected together by an arrow, one confirming/corroborating the existence of the other as shown in figure 14 below.

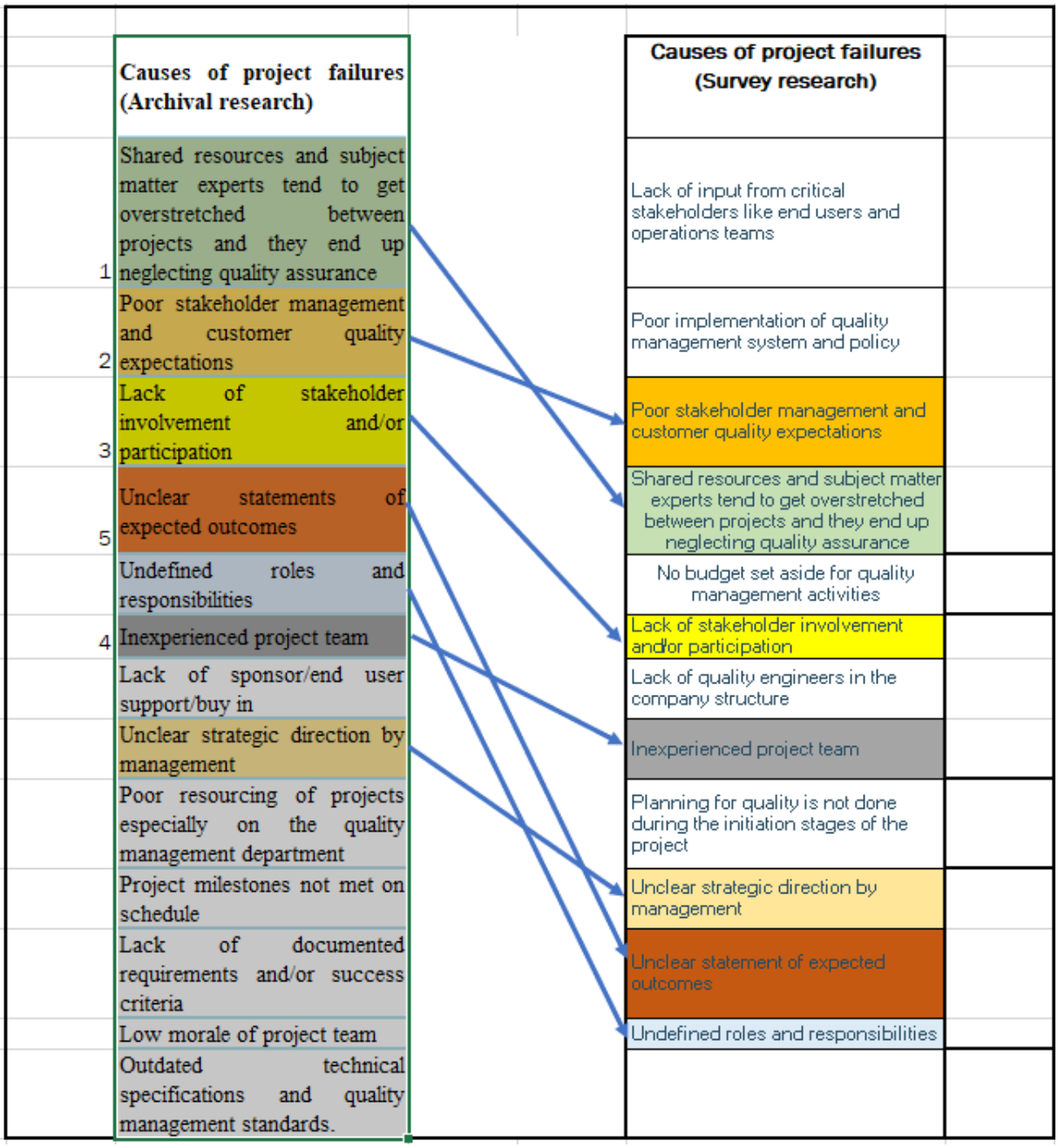

Figure 15: triangulation of archival & survey research results.

Source: Author, adopted from Cresswell (1999).

The results from triangulating the survey and archival research were used to determine the top 5 causes or major causes of project failure in Debswana. The top 5 were determined based on the frequency of appearance of each cause on different survey questionnaires, and how often it appeared on the archival document reviews. The one that appeared more was placed number 1 and so on until number 5. These are listed in table 35 below

Table 5:List of top five (5) causes of project failure in Debswana.

Position	Cause of project failure
1	Shared resources and subject matter experts get overstretched between different projects and end up neglecting quality assurance
2	Poor stakeholder management
3	Lack of stakeholder involvement and participation in the project
4	Inexperienced project team
5	Unclear statements of expected quality outcomes

4.4 Summary of results

The aim of this study was to assess and evaluate the maturity level of the quality management system in Debswana projects as well as its adoption and implementation, through the research objectives. From the research results it is evident that a QMS framework does exist in Debswana and is at a high level of maturity though it has not reached the level of being fully optimised. From a QMS maturity assessment point of view, the Debswana project QMS can be said to be at level 4 where processes are measured and controlled (see figure 6 below). This was arrived at looking at the maturity indicators and the set criteria. From the survey results and archival research results, Debswana does have a single point of truth which is the company information repository portal where all the company documents are kept including QMS policies and procedures. This is accessible through the company intranet. The governance protocols around information management are also in existence and strict measures are in place for information security. These are some of the maturity indicators that qualifies Debswana QMS maturity level to be at a 4. The results further shows that there is information integration and data warehousing with a completely remote disaster recovery facility. This together with information accountability, impact assessment and risk management protocols are the criteria that further qualifies the maturity level of 4. The gaps identified need to be closed for the maturity level to move up to optimised and focus on process improvement. The gaps are mainly around operationalisation, lower-level employees training on quality management, optimisation of shared resources especially subject matter experts like project engineers, key stakeholder management, involvement and participation from end users and operations teams.

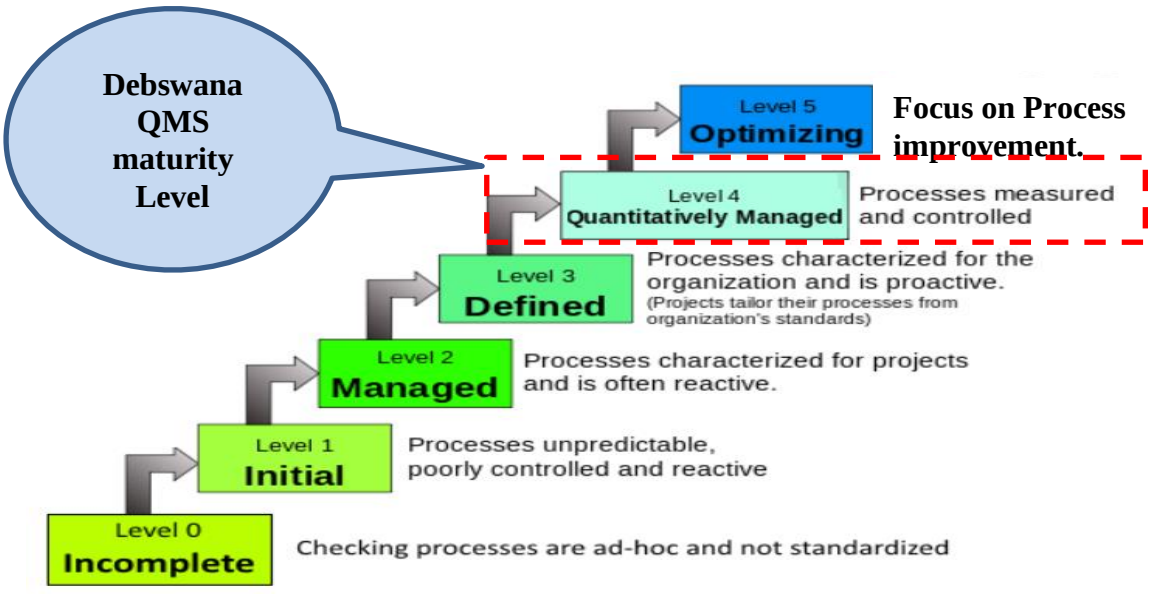

Figure 16: Debswana QMS maturity model.

Source: Author, Adopted from Baskarada, 2009

CHAPTER 5: DISCUSSION

This research work sought to evaluate the adoption and implementation of quality management in major projects in the Botswana mining industry. The literature reviewed provided an in-depth understanding of the principles of project management, project quality management, quality management systems and the prevalent practices thereof, in the Botswana mining industry. Archival research and surveys were conducted to evaluate the adoption and implementation of the quality phenomenon. These were guided by the research objectives below:

i. Determine the major causes of project failures related to quality management in Botswana Mining Industry.
ii. Investigate the level of adoption and implementation of the quality management system (QMS) in projects in Botswana Mining industry.
iii. Evaluate the effectiveness of quality management systems and processes in Botswana Mining Industry and identify gaps for improvement.

The first research objective for this study was to investigate the level of adoption and implementation of quality management system in projects in Debswana.

Three (3) constructs under this objective were investigated, to measure the level of adoption and implementation of QMS in Debswana. These were **systems and procedures**, **Quality control and Assurance** and the **operationalisation of the QM system**. It is evident from the survey results that there are systems and procedures to manage project quality in Debswana and they are aligned to international standards however there are gaps when it comes to the employee involvement and knowledge in the different processes. This raises an issue of employee training on quality management. Regarding quality control & quality assurance, the results show that QC/QA is done at every stage of the project lifecycle even though most survey respondents are not aware of whether third party quality assurance is done by an approved institution or not. However, this was confirmed through archival research which showed that third party Quality Assurance is part of the Quality Management system and third-party institutions like iSithelo (Former Anglo technical services), Geoflux Botswana and others are always engaged to give assurance to Debswana. In terms of QMS operationalisation, it became evident from the survey results that the level of operationalisation of the Quality Management system is satisfactory, but with a gap identified around the understanding of system requirements by lower-level employees which needs to be further investigated and corrected through QMS training roll out.

The second research objective was to evaluate the effectiveness of quality management systems and processes in Debswana and identify gaps for improvement.

To evaluate the effectiveness of QM systems and processes, there were also three (3) constructs that were assessed. These include **QMS understanding**, **Quality management feedback and continuous improvement as well as Supplier quality management**. From the survey results, there are more positive sentiments about the respondents' understanding of a QMS and its intended purpose. The results also indicate that supplier quality management exists and that Debswana works closely with its external suppliers towards long term partnership and improvement. There is evidence that the quality control processes allow for stage gate releases of critical equipment under design, fabrication, or repairs at suppliers' sites. This can provide a platform for defects to be picked during early stages of the project and corrected on time. In terms of the feedback and continuous improvement construct, the results show that, even though there is a QMS, feedback and continuous improvement measures like customer satisfaction, and that the company practices continuous improvement of services and products, there are still a lot of problems associated with quality in the major projects. As a result of this, the researcher went further to investigate the actual causes of these quality related problems, which is the last objective of this study.

The last objective of the study was to determine the major causes of project failures related to quality management in Debswana.

The first two objectives of the research were achieved, and their results show that Debswana has a Quality Management system in place and rigorously implements the system's processes and procedures. These are deemed to have a satisfactory level of effectiveness. However, there are problems associated with quality in the projects space in Debswana. Therefore, the last objective was to establish the top 5 major causes of project failures related to quality management in Debswana projects. This was done through survey research and the results corroborated through archival research. The top five (5) major causes of project failure have been identified as per the list below in the order presented:

6. Shared resources and subject matter experts get overstretched between different projects and end up neglecting quality assurance.
7. Poor stakeholder management
8. Lack of stakeholder involvement and participation in the project
9. Inexperienced project team
10. Unclear statements of expected quality outcomes

Overall, the objectives of the study were achieved, gaps were identified, and recommendations brought forward to try and close the identified gaps.

It should be noted that, from table 4 above, the top cause of project failure is attributed to under resourcing of projects specialized skills and subject matter experts like engineers. These resources end up being overstretched between roles and in the long run they neglect quality assurance which will result in poor quality products or total project failure. This is seconded by stakeholder management and involvement, where stakeholders are not engaged in all the project stages and are expected to receive the product of the project. This is detrimental because stakeholders and end users are very critical to give operational input using their experience and user requirements. Lack of engaging them can result in a project which is not fully accepted or a solution that does not address the current problems to the fullest. One of the issues is the inexperienced project team. This has been demonstrated clearly when new employees are hired into the projects department from outside the organization and they come with theoretical knowledge of projects but lack the necessary experience and insights of the mining operations. They end up with solutions not aligned to the business requirements. The last cause of project failure is attributed to unclear statement of expected quality outcomes which directly implies that quality planning is not done right, because that is the stage where all expected quality outcomes are stated out and agreed upon including the standards and procedures to be complied with. This can also cause problems during quality control and quality assurance exercises where the assuring body/person must gauge compliance to a set of agreed outcomes, which by then will be non-existent. These findings were expected as they have also been consistently appearing in the literature review.

From the survey results it is evident that there are systems and procedures to manage project quality, and they are aligned to international standards, however, there are gaps when it comes to the employee involvement and knowledge in the different processes. This was found to be attributed to employee training on quality management. Regarding quality control & quality assurance, the results have shown that QC/QA is done at every stage of the project lifecycle. Archival research showed that third party Quality Assurance is part of the Quality Management system and third-party institutions like iSithelo (Former Anglo technical services), Geoflux Botswana and others are always engaged to give assurance to Debswana. In terms of QMS operationalisation, it became evident from the survey results that the level of operationalisation of the Quality Management system is satisfactory, but with a gap identified around the understanding of system requirements by lower-level employees which needs to be further investigated and corrected through QMS training roll out.

An unexpected finding came up from the research that another cause of project failure was the lack of a site instruction document. The site instruction document is a template/form used to manage scope creep on site, where any ad hoc instructions outside of the approved scope issued to contractors and execution teams on the ground are noted down, approved by the project manager and engineers so that they are made aware of such requirements. In the absence of this form, anyone can instruct contractors to do extra work which will result in additional work, cost, and extension of time. A site instruction is a standard form of contract administration found on construction/mining projects. The document provides a direction to the contractors on site to proceed with a change in the design or scope. In some instances, it may mean no cost, however, on some projects it requires a cost to be submitted by the contractor, (PMBOK Guide, 2017). This unexpected finding raises the need to have a properly documented project communication plan with a clear RACI matrix (who is Responsible, Accountable, Consulted and Informed) when it comes to project decisions.

In general, the expectations from the literature review and the observations from the survey and archival research did not deviate from each other, but they rather corroborated and complemented each other. Triangulation of the two research methods provided a confirmation of the research results.

The findings of this study have answered the critical research question, 'What is the status of the adoption and implementation of quality management systems (QMS) in Botswana mining companies in relation to major projects?'.

From the research results it is evident that a QMS framework does exist in Debswana and is at a high level of maturity though it has not reached the level of being fully optimised. From a QMS maturity assessment point of view, the Debswana project QMS can be said to be at level 4 where processes are measured and controlled. The gaps identified need to be closed for the maturity level to move up to optimised and focus on process improvement. The gaps are mainly around operationalisation, lower-level employees training on quality management, optimisation of shared resources especially subject matter experts like project engineers, key stakeholder management, involvement and participation from end users and operations teams.

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

This study sought to evaluate the level of adoption and implementation of quality management system in the Botswana mining industry. This was motivated by the researcher's observation that emanated from his professional experience where he observed that major projects always have problems related to quality and some of them even don't deliver the intended outcome. The researcher being a maintenance professional has had to deal with a lot of post project completion issues as the end user of the products of many mining industry projects like new plant designs, equipment overhauls, plant shutdowns, new equipment assembly, infrastructure and workshops erections, and this ultimately prompted him to carry out a study to evaluate the implementation of quality management in such big magnitude projects as well as establishing the top-ranking causes of project failures.

The objectives of the study were achieved, and the critical research question was answered through archival research and surveys.

Whilst a quality management system has found to be existent, its maturity level still has a lot of room for improvement which can take it to the next level of being optimised and major focus directed at process optimisation. There were some limitations to the study which included the limited number of archival documents from the internal repositories where past projects learnings could be retrieved. There was also limited literature available specifically past research done with respect to the Botswana mining landscape.

The researcher has identified some gaps in the Debswana Quality Management System and has provided suggestions/recommendations which can add some value and probably move the maturity level closer to the optimised level. These are as follows:

1. Roll out a focused intensive training on the QMS requirements, processes and procedures to the operations teams and end users to derive value out of their day-to-day work and input to quality management.
2. Review the resourcing model for the project management office. Shared resources are a good idea for resource optimisation and utilisation, however when it comes to subject matter experts, a closer look should be made. This should be cognisant of the project magnitude and scope of works; large projects need to have 100% dedicated subject matter experts who are not shared between projects. These include discipline-specific engineers and project managers.

3. The organisation should consider employing quality engineers whose sole responsibility will be to focus on quality. This would remove the load of discipline-specific engineers doubling up as quality engineers.
4. The organisation should come up with initiatives that will improve the participation of end users and operations teams in the different stages of the project life cycle before the product is handed over. This will ensure end user requirements are catered for at the initial stages of the project especially considering that the project team is based in head office, located away from the mining operations and are not privy to the dynamic challenges and changes occurring daily at the operational sites.
5. The organisation should review the quality requirements during quality planning stage to have clear statements of expected quality outcomes. This should be well aligned to the quality standards and procedures that the product is expected to comply with.
6. Lastly, the research should be further expanded to quantify the monetary loss associated with poor quality of the end products of major projects in the mining industry in Botswana, considering that the mining industry has a large contribution to the country's economy.

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APPENDICES

SURVEY ON THE ASSESSMENT OF THE MATURITY LEVEL OF QUALITY MANAGEMENT SYSTEM IN DEBSWANA PROJECTS.

Introduction

Kindly take a few moments from your busy schedule and fill in the questionnaire. Your participation is voluntary, and you can withdraw at any time without being penalised. Throughout the survey your privacy will be protected, and your participation will remain confidential. There will be high levels of anonymity as you are not required to disclose your particulars.

Demographic data

This section seeks to establish demographical information of the survey participants for results analysis and has no any other intended purpose apart from that. Please tick the circle that applies to you.

Gender	Male ◯	Female ◯	
Age	20-35 ◯	36-45 ◯	46-60 ◯
Operation	DCC ◯	Jwaneng ◯	Orapa ◯
Employer	Debswana ◯	Business Partners ◯	
Department	Engineering ◯ Projects ◯	Mining ◯ PMO ◯	CMO ◯

Appendix 1:Survey questionnaire front page

Section 1: Measuring the effectiveness of the QMS processes and Procedures

This section seeks to evaluate the effectiveness of the existing Debswana QMS processes and procedures. Please circle the number that best represents your level of agreement.

0= Don't know 1= strongly disagree 2= Disagree 3=Neutral 4= Agree 5=strongly agree

Effectiveness of the Debswana QMS	Level of agreement
QMS understanding	
1. QMS is a management philosophy and practice to ensure effective and efficient use of all available resources	0 1 2 3 4 5
2. QMS aims to achieve customer satisfaction	0 1 2 3 4 5
3. Training and education are vital elements with respect to QMS	0 1 2 3 4 5
4. Debswana has developed a clear quality policy	0 1 2 3 4 5
5. Do you think the Quality management system really works in Debswana?	0 1 2 3 4 5
Quality Management, feedback & Continuous Improvement	
6. Customer satisfaction levels are measured and monitored	0 1 2 3 4 5
7. Feedback on quality from customer satisfaction surveys is collected and analysed	0 1 2 3 4 5
8. There is a quality improvement coordinating body (eg quality steering committee)	0 1 2 3 4 5
9. The company practices continuous improvement of all its products, services and processes.	0 1 2 3 4 5
10. Employees' views and listened to and acted upon.	0 1 2 3 4 5
11. There are no quality associated problems in major projects	0 1 2 3 4 5
Supplier Quality Management	
12. Suppliers are selected based on quality service delivery	0 1 2 3 4 5
13. Debswana regularly conducts suppliers' quality audits	0 1 2 3 4 5
14. Debswana works closely with suppliers towards long term partnerships and improvement	0 1 2 3 4 5
15. Quality management procedures allow for inspection and stage gate releases of critical equipment under design, fabrication or repairs at supplier workshops.	0 1 2 3 4 5

Appendix 2: survey questionnaire section 1

Section 2: Investigating the level of Adoption and Implementation of QMS in Debswana Projects

This section seeks to investigate the level of adoption and implementation of QMS in Debswana projects, both at projects office and at operational level. Please circle the number that best represents your level of agreement.

0= Don't know 1= strongly disagree 2= Disagree 3=Neutral 4= Agree 5=strongly agree

Adoption, Operationalisation and Implementation of the QMS in Debswana projects	Level of agreement
Systems and processes	
1. QMS Systems and procedures for Quality management exist and are implemented	0 1 2 3 4 5
2. The employees involved in different processes know how to use them. Eg (initiating, planning, execution, oversight)	0 1 2 3 4 5
3. Quality Control checks are done during all stages of the project	0 1 2 3 4 5
4. Quality management standards are aligned to international standards like ISO standards.	0 1 2 3 4 5
Quality Control and assurance	
5. Quality requirements are clearly stated at the early stage of the project (during scope development)	0 1 2 3 4 5
6. Third party quality assurance is carried out for all major projects by an approved quality management institution.	0 1 2 3 4 5
7. Debswana subscribes and is certified for ISO quality management standard. Eg (ISO 9001 QMS)	0 1 2 3 4 5
8. Debswana has technical standards which specify clearly the quality requirements for all stages of the project lifecycle.	0 1 2 3 4 5
9. Quality Control checks are done during all stages of the project	0 1 2 3 4 5
QMS operationalisation	
10. Employees understand the quality management system requirements at all levels	0 1 2 3 4 5
11. Employees are empowered to make suggestions for quality improvement	0 1 2 3 4 5
12. Contractors and subcontractors are held accountable for poor quality work.	0 1 2 3 4 5

Appendix 3: Survey questionnaire section 2

Section 3: WHY DO PROJECTS FAIL?

This section seeks to determine the major causes of project failures related to quality management in Debswana. Please circle the number that best represents your level of agreement.

0= Don't know 1= strongly disagree 2= Disagree 3=Neutral 4= Agree 5=strongly agree

Determination of major causes of project failures in Debswana	Level of agreement
Management support and guidance	
1. Lack of sponsor/end user support/buy in	0 1 2 3 4 5
2. Unclear strategic direction by management	0 1 2 3 4 5
3. Inexperienced project team	0 1 2 3 4 5
4. Lack of stakeholder involvement and/or participation	0 1 2 3 4 5
5. Lack of documented requirements and/or success criteria	0 1 2 3 4 5
Project Management	
6. Low morale of project team	0 1 2 3 4 5
7. Shared resources and subject matter experts tend to get overstretched between projects and they end up neglecting quality assurance.	0 1 2 3 4 5
8. Poor resourcing of projects especially on the quality management department (lack of quality engineers).	0 1 2 3 4 5
9. Outdated technical specifications and quality management standards.	0 1 2 3 4 5
10. Project milestones not met on schedule	0 1 2 3 4 5
11. Poor stakeholder management and customer quality expectations	0 1 2 3 4 5
12. Unclear statements of expected outcomes	0 1 2 3 4 5
13. Undefined roles and responsibilities	0 1 2 3 4 5
14. Project benefits not clearly defined	0 1 2 3 4 5
15. Lack of communication between the project team members	0 1 2 3 4 5
16. Budget cuts	0 1 2 3 4 5
17. Ineffective schedule planning and management	0 1 2 3 4 5
18. Scope creep	0 1 2 3 4 5

Appendix 4: Survey questionnaire section 3

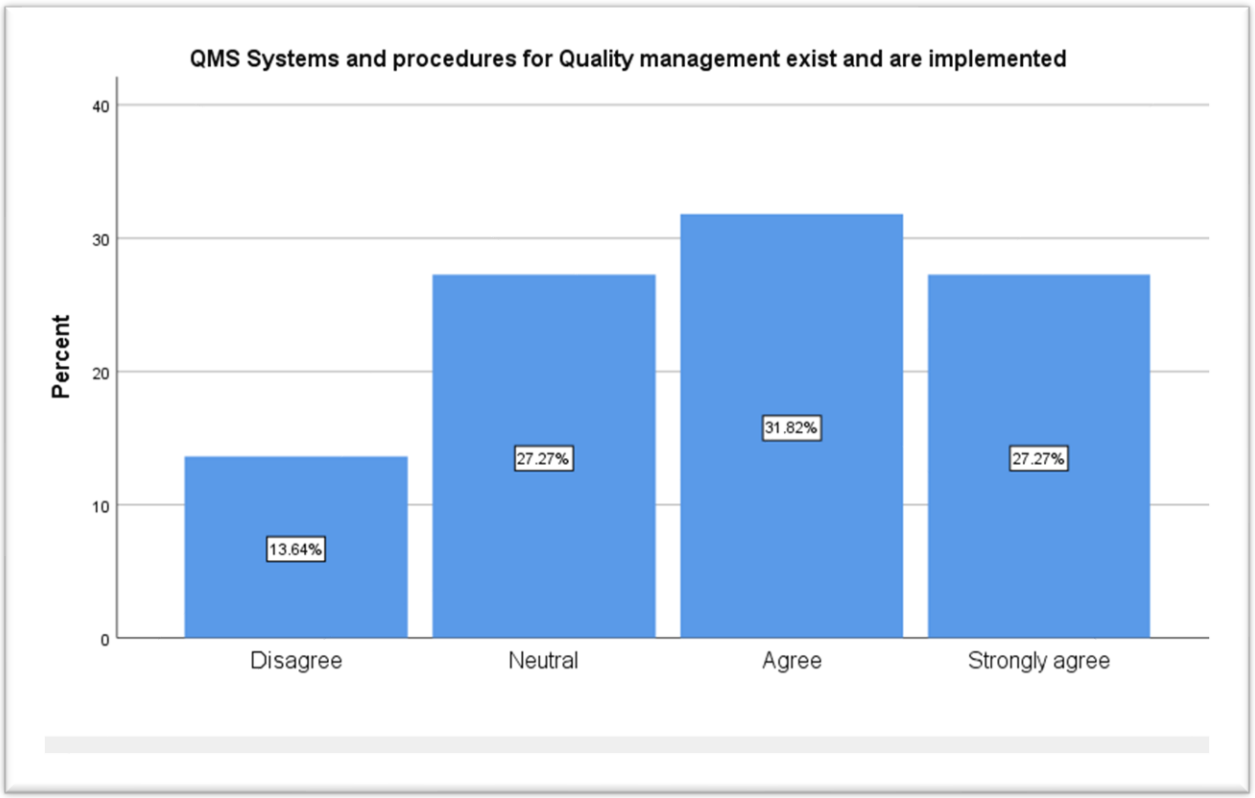
Statistics						
		QMS is a management philosophy and practice to ensure effective and efficient use of all available resources	QMS aims to achieve customer satisfaction	Training and education are vital elements with respect to QMS	Debswana has developed a clear quality policy	Do you think the Quality management system really works in Debswana?
N	Valid	88	88	88	88	88
	Missing	0	0	0	0	0
Modal answer		Agree	Strongly Agree	Strongly Agree	Neutral	Neutral

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	4	4.5	4.5	4.5
	Disagree	4	4.5	4.5	9.1
	Neutral	4	4.5	4.5	13.6
	Agree	52	59.1	59.1	72.7
	Strongly agree	24	27.3	27.3	100.0
	Total	88	100.0	100.0	

		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	**Neutral**	**24**	**27.3**	**27.3**	**27.3**
	Agree	**16**	**18.2**	**18.2**	**45.5**
	Strongly agree	**48**	**54.5**	**54.5**	**100.0**
	Total	**88**	**100.0**	**100.0**	

Appendix 5: Sample survey results

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	36	40.9	40.9	40.9
	Strongly agree	52	59.1	59.1	100.0
	Total	88	100.0	100.0	



Appendix 6: Sample bar graph analysis of survey results