The application of a stage-gate method to manage projects at an academic research centre in South Africa

PM Modisha

orcid.org/0000-0002-3197-2297

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Supervisor: Prof JN Lekunze

DECLARATION

I, Phillimon Mokanne Modisha, hereby declare that this mini-dissertation submitted to the North-West University in partial fulfilment of the degree of Master of Business Administration (MBA) is my original work. All content and materials used in this mini-dissertation have been properly cited and the sources used are listed accordingly. This is an original version of my mini-dissertation and has not been submitted to any other university or publishing house.

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ABSTRACT

The study focused on exploring the application of the Stage-Gate method for managing research and development (R&D) projects within academic research centre in South Africa. There is a need for R&D centres in academic institutions to seek alternative methods of managing projects due to the inefficiencies and financial implications of the current methods. In this study, the qualitative exploratory-descriptive research design was used and this is underpinned by the interpretivist research paradigm with an inductive approach. The study was conducted in one academic research centre and the population included all employees that are involved in R&D projects. This study took place over a single period in the short term due to limited time and resources. A convenience nonprobability sampling technique was used and the data was collected through semi-structured interviews, involving a total of 15 participants from engineering and scientific professional backgrounds. The collected data was transcribed and the thematic analyses were then employed to interpret the patterns and themes. It was found that the research centre uses informal and unstructured project management methods to run R&D projects. Therefore, challenges such as poor communication, scope creep, procurement issues, and cost overruns were experienced. Above all, the incorporation of agility in the Stage-Gate method as well as the quality control or gatekeeping by management and project leaders will mitigate the challenges mentioned. The partial alignment of the current unformal method with Stage-Gate suggests seamless implementation. Furthermore, the availability of a skilled R&D team, support from management and clear organisational goals regarding commercialisation point in the right direction towards product launching. A formal Stage-Gate method will assist in the expedition of the transition from R&D to market launch. Based on the findings, Stage-Gate must be customised as follows: Engineering projects are high-risk and complex, and therefore a five-step method is suitable. Most scientific projects are low to medium risk and a three-step method can be used. The Stage-Gate method can help an organisation improve its strategic planning, policy development, operational efficiency, and, ultimately, its ability to achieve long-term success. Recruiting a team of representatives from R&D, commercial law, marketing, finance, and other strategic and policy divisions can foster diverse perspectives and collaborative problem-solving for the successful implementation of the Stage-Gate method. Management should execute a Stage-Gate pilot programme that will help to customise the method based on the risk level and the practical insights of each project.

Keywords: Stage-Gate; Project management; Commercialisation; R&D Centre; Implementation; Idea-to-launch; Critical-success factors

LIST OF ABBREVIATIONS

IP: INTELLECTUAL PROPERTY

KPI: KEY PERFORMANCE INDICATORS

NPD: NEW PRODUCT DEVELOPMENT

POPI: PROTECTION OF PERSONAL INFORMATION

R&D: RESEARCH AND DEVELOPMENT

ROI: RETURN ON INVESTMENT

SME: SMALL-TO-MEDIUM ENTERPRISE

VOC: VOICE OF CUSTOMER

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CHAPTER 1

OVERVIEW OF THE STUDY

1.1. Introduction and background

The purpose of this study was to explore the application of the Stage-Gate method as an alternative project management tool to the traditional Waterfall project management approach used by research and development (R&D) centres in the management of projects. The Stage-Gate method is defined by Cooper (2010:1) as a *playbook*, *game plan*, or *road map* that is used to guide new-product ventures from conceptualisation to product launch phase. The Stage-Gate method exists in phases, such as ideation, preliminary investigation, building the business case, development, testing and validation as well as pre-commercialisation. A criterion is set to determine whether the project should proceed to the next phase, stopped or whether the project requires further improvement. There are several alternative methods to guide new product ventures, such as lean startup (Bortolini *et al*., 2021:1765), design thinking (Dell'Era *et al.,* 2020:324-327), waterfall (Thesing *et al*., 2021:747), agile development (Silva *et al*., 2020:595-598), and customer development (York & Danes, 2014:21-27). The Stage-Gate method was deemed superior to other methods due to its structured and systematic approach that emphasises addressing market and customer needs, the integration of customer feedback, and effective in the management of project risks (Cooper, 2006:20).

Cooper (2010:1-3) also explained that the Stage-Gate method is a blueprint for controlling the product and service innovation process with the intention of improving effectiveness and efficiency. Wuest *et al*. (2014:33) are of the view that the Stage-Gate method is the most appropriate technique for determining project decision points known as gates during a product development process. Stošić and Milutinović (2014:1702) further defined the Stage-Gate method as a value-creation business process that aims to transform an organisation's innovative ideas quickly and profitably into new products and services. In this study, Stage-Gate is conceptualised from the position of transforming ideas through R&D to create new products. Therefore, the conceptualisation of the Stage-Gate method in this study is aligned with the definition of Cooper (2010:1), who is the founder of this method.

The implementation of the Stage-Gate method is popular in software development, but the method has been adopted by industries in different sectors of the economy such as manufacturing, mining, food and beverages, energy, pharmaceutical, chemical and petrochemicals (Bianchi *et al*., 2020:538; Dunn *et al*., 2011:21; Edgett, 2015:1; Uchihira, 2005:1). Edgett (2015:1) explained that over 80 percent of companies in North America are using the Stage-Gate innovation method. The Stage-Gate method is preferred by many companies in North America because it provides a structured, flexible approach to innovation that promotes collaboration, risk management, continuous improvement, and a focus on customer needs (Edgett, 2015:1). These benefits make it a highly effective innovation method that is well-suited to the needs of many companies.

The research centre in which the Stage-Gate method is to be applied is currently utilising the traditional Waterfall method to manage projects. Therefore, the Waterfall method is emphasised in this discussion. The traditional Waterfall approach was first introduced by Winston Royce in the 1970s (Pace, 2019:57) as a sequential project management strategy with a linear development approach in which the bulk of project deliverables and stakeholder needs is determined at the onset and formalised into a rigid development plan (Thesing *et al*., 2021:747; Adenowo & Adenowo, 2013:429). Van Casteren (2017:1), in his study, indicated that there are five phases of the Waterfall method, namely (i) requirements, (ii) design, (iii) implementation, (iv) verification, and (v) maintenance. The limitation to the Waterfall approach was that it makes no provision for iteration in the flow from one phase to the next. As such, Petersen *et al*. (2009:386-388), and Ismail and Mansor (2018:5216-5218) explained that the problems associated with the Waterfall method are related to the non-flexibility of project specifications as they are locked (no iterations, fixed budget and timeframes), resulting in a once-off delivery of products to a client or nothing to the client.

As Petersen *et al*. (2009:386-388) put it, the outcome from the application of a Waterfall method in any product design is binary, in which case it is either a project success or project failure due to the rigidity of the method in forcing integration and customer testing to be the last phase of a project. Therefore, it is only in the testing phase that a client gets to see the long-awaited product after huge investments and efforts have been made with a high risk of failure (van Casteren, 2017:1-2). As a result, trying to troubleshoot defects in a completed system is a time-consuming, challenging and expensive process that may further cost project over-run in terms of costs, time and scope.

In academic R&D, external *ad-hoc* projects are likely to shift the focus on the main projects. Similar to this, the unplanned innovation requires careful management to avoid diverging from the core projects and wasting time and resources on ideas that are not likely to succeed. In this case, the gatekeeping in the Stage-Gate method will play a major role in streamlining the projects according to the objectives of the R&D centre. The traditional Waterfall approach has been used to respond to the abovementioned disruptions; however, due to its inflexibility, delays in the real value of projects have been experienced (Legowo & Aditama, 2020:3528,3529,3532). Kramer (2018:79) explained that if there are no iteration and feedback along the stages of a project, it will be difficult to improve initial imperfections. Moreover, it is risky to put the testing phase near the completion of the project as problems or unplanned setbacks could lead to fruitless expenditure. Inflexible approaches are not feasible for complex projects and may also limit the customer to preview the project until it is too late to make changes (Alshamrani & Bahattab, 2015:108).

Numerous projects are exciting and mind-blowing, but are they commercially viable? Should the research centre invest heavily in these projects? An application of the Stage-Gate method in the chosen academic R&D centre may result in the implementation of these key aspects to manage projects to mitigate risks in the following ways: (i) planning of activities needed to reach a particular goal, (ii) directing and motivating by mobilising qualified personnel for a particular project, (iii) controlling by ensuring that the activities are executed according to the plans, and (iv) decision-making on whether the project is worth further investments. As such, the discussed limitations to the Waterfall method to product development justifies the need for shifts from the current approach used by an R&D centre of an academic institution in South Africa. The Stage-Gate method may not be generally applied to different types of projects, it must be custom-designed based on the type of projects and the strategic requirements of an organisation (Smolnik & Bergmann, 2020:51-53).

1.2. Problem statement

The suitability of using a Stage-Gate method for managing innovation as well as R&D projects is still being debated in project management literature and case studies on its implementations are rare (Högman & Johannesson, 2013:264). Charvat (2003:4) opined that there is no single universally acceptable project management method that fits all projects. Meanwhile, Ettlie and Elsenbach, (2007:21,22) suggest that the generic version of the Stage-Gate method cannot be applied in an organisation without iterations to fit the specific project needs. Yaw Koi-Akrofi *et al*. (2019:38-39) reported that R&D centres have mostly used methods that are aligned with the traditional Waterfall approach to manage projects, but it is monolithic, slow, rigid and has limited flexibility. The inefficient management of scope creep has been one of the main challenges that resulted in fruitless expenditure, delays and missing of planned deadlines within the academic research environment. Fundamental research is a big challenge in academia because many ideas do not directly address tangible business issues. All *new ideas* are not *winning ideas* and without a proper system of evaluation and screening new ideas, time and resources are wasted on non-valuable R&D projects. On the other hand, new inventions can easily slip without being noticed when there is a lack of an innovation management system. The lack of effective project monitoring and controlling mechanisms, including a lack of communication between researchers and project managers in academic research, can hinder the success of R&D projects and thereby limit commercialisation efforts.

1.3. Research aim and objectives

The aim of this study was to explore the implementation of the Stage-Gate method as an alternative to the traditional Waterfall method for the management of research and development (R&D) projects at a research centre hosted by an academic institution in South Africa. Based on the aim of the study, the objectives of this study were:

- To describe the current project management approach used at the research and development centre.
- To explain the management challenges with the ongoing projects caused by the current management approach.

- To describe the enablers for a successful implementation of a Stage-Gate method as an alternative management tool in the centre.
- To establish the critical success factors of the Stage-Gate method in a research and development centre.
- To customise the Stage-Gate method to align with the objectives of the research and development centre, and
- To propose a strategic guideline to assist in building a business case for products developed within the research centre.

1.4. Research questions

Based on the aim of the study, the primary question was: "How does the implementation of the Stage-Gate method compare to the traditional Waterfall method in managing research and development (R&D) projects at a research centre hosted by an academic institution in South Africa?" To answer this question, the following sub-research questions were postulated:

- What is the current project management approach used at the research and development centre to manage its projects?
- What are the existing project management challenges about ongoing projects caused by the management approach in place?
- What are the enablers for the successful implementation of a Stage-Gate method as an alternative management tool in the centre?
- How does the critical success factors of the Stage-Gate method in a research and development centre minimise the existing management challenges?
- How is the Stage-Gate method customised to align with the objectives of the research and development centre? and
  How would a proposed strategic guideline for the implementation of the Stage-Gate method assist in building a business case for products developed in the research centre?

1.5. Scope and delimitation of this study

Theofanidis and Fountouki (2018:156) suggest that limitations to a study are potential weaknesses beyond a researcher's control that may impact the outcome and results of a study. The present study is qualitative and due to the nature of qualitative studies, which are based on the subjectivity of participants, the findings of the study may not be generalised to all academic research centres. However, the methodological approach used is sound and can be adopted by studies that focus on other research centres across South Africa.

Furthermore, this study focuses on the implementation of the Stage-Gate method in managing R&D projects. Specifically, the study will be limited to employees who are involved in applied engineering research, particularly in the field of clean energy. This is because the energy sector faces significant challenges that require urgent attention. One of the key challenges is the negative impact of greenhouse gas emissions on the environment, which calls for the development and adoption of cleaner and more sustainable energy sources. Another challenge is the ageing infrastructure in the energy sector, which requires innovative solutions to ensure a reliable and affordable energy supply.

1.6. Significance of the study

The study intends to provide insights into how the Stage-Gate method can be used to effectively manage R&D projects in the field of energy research, with a focus on developing practical and actionable solutions that can be implemented quickly. The study was conducted at a research centre hosted by the North-West University, Potchefstroom Campus in South Africa. The research centre is a hub of innovation and creativity, with a project-oriented approach that is like that of a corporate R&D division. The centre is well-suited for the study because it provides a collaborative and interdisciplinary environment for researchers to work on cutting-edge technologies and solutions. Additionally, the centre’s mandate to develop and commercialise new technologies makes it an ideal setting for conducting research on the implementation of the Stage-Gate method.

Furthermore, unstructured project management approaches may lead to the overspending of the budgeted amount of the project due to delays, discovering of technical problems too late, lack of accountability and disordered management (Kassa, 2020:102; Kasauli *et al*., 2020:31; Walker, 2017:180-185). Unstructured project management approaches may also lead to spending too much time and funding on a non-commercially viable R&D. On the other hand, the most viable innovation may slip without being noticed as there is a lack of a structured approach to innovation management. This could potentially impede commercialisation, particularly in an academic environment. It is the intention of this study to contribute to the existing literature by providing a systematic project management tool called Stage-Gate, which will be tailored for academic research and development projects. This was done by first exploring the experiences of the employees involved in projects, exactly how the projects are coordinated and what the challenges faced are. The audiences who will benefit from this study include academic researchers, policymakers, strategists, engineers, project managers, and general managers, who are likely based at research and development departments or institutions such as CSIR and Mintek, academia, the Department of Science and Innovation, and start-up companies.

1.7. Definition of concepts

In a qualitative study, the definition of key concepts plays a crucial role in explaining how these constructs in a particular study should be interpreted within context. In this study, while the constructs used may be common in business management literature, the contextualisation and operationalisation of these constructs as an application to this research are useful to put the reader into context and scope. The following key concepts are defined based on the context of the Stage-Gate method. This is to specify and provide a clear differentiation between what it is meant and what is not meant to be the terms used in this research.

Adaptability: The ability to deal with the expected responsibilities of preparing for and engaging in a role, as well as the unanticipated adjustments caused by changes in the work itself and working conditions (Savickas, 1997:254).

Business plan concept: A detailed techno-economics research and market survey to determine customer preferences, market size, customer segment, and competitors (Cooper, 1990:52,53). Economic analysis includes expenditures, cost benefits, make-or-buy decisions, and sensitivity analyses.

Development: Progressing to a more advanced stage, a detailed testing of the prototype, evaluation of scalability and operation plans include resolving intellectual property or copyright issues (Cooper, 1990:52,53)

Feasibility: An evaluation of the technical and/or economic viability of a given project plan or approach. Halil *et al*. (2016:57) define feasibility as the evaluation of project viability by risk assessment, financial assessment (profitability), and economic assessment as well as social and environmental issues.

Freedom to operate (FTO)**:** The capacity to utilise your technology without infringing on the intellectual property of third parties. Kowalski, (2007:1329) defines FTO as the capacity to proceed with the research, development, and/or commercial activities of a novel product with a low risk of infringing unlicensed intellectual property (IP) or tangible property (TP) rights of other parties.

Flexibility: The ability of project management to add resources as buffers to account for any form of unforeseen project dynamics and changes in specifications.

Gate: A decision-making point to determine whether to continue with a project, hold to gather more information or stop permanently (Cooper, 1990:52,53).

Gatekeeper: An individual or stakeholder responsible for making the decision to continue with a project, hold to gather more information, or stop the project permanently.

Ideation: It is a process of brainstorming and discovering new, creative and novel concepts or ideas that are submitted to a gate for evaluation (Cooper, 1990:52,53). This involves an extensive literature review including intellectual property screening.

Preliminary investigation/scoping: The assessment of the technical feasibility and market potential of the idea/concept at a low cost and short time (Edgett, 2015:4); generally known as soft-screening or desk research.

Product launch/commercialisation: It is defined as the commercial roll-out of the product to the general market and testing its performance. Operation plans, sales materials and marketing launches are implemented (Edgett, 2015:4).

Screening: Identifying and keeping track of available technologies, and competitor patents that may restrict the launch of a product in a certain market.

Stage: A time between gates in the Stage-Gate process during which actions are carried out with the goal of accumulating information to pass through a gate in the future.

Techno-economic analysis: Quantitative evaluation of the economic performance as well as the environmental impact of a product or service (Oughton & Lehr, 2021:5).

Testing and validation: In-house testing and field trials to validate the product in a real-life working environment. This includes market testing pilot demonstrations to potential customers or end users.

1.8. Conceptual framework and methodology

The study is grounded in the interpretivist research paradigm, a theoretical framework that uses qualitative research methodology to emphasise the socially constructed nature of reality and the subjective interplay between researcher and subject (Bryman & Bell, 2014:342). By adopting this paradigm, the research seeks to understand and interpret the meanings and experiences of participants. It leverages the philosophical branch of epistemology to explore the knowledge, beliefs, and justification related to the implementation of the Stage-Gate method in a research centre of a South African higher learning institution (Maarouf, 2019:8; Yulianto, 2021:159). The study uses an inductive approach, underpinning the research methodology, to construct new meaning from gathered data.

The primary data for this research is collected through empirical investigation, providing first-hand insights into the implementation of the Stage-Gate method. The primary data collection method employed is semi-structured interviews, which allow for detailed exploration of the subjective experiences of participants, facilitating the emergence of themes and patterns from their responses.

The population of the study includes employees of a research centre at the North-West University, Potchefstroom Campus, South Africa. This study employed a non-probability sampling technique known as convenience sampling since it was a case study. As defined by Etikan *et al.* (2016:2), convenience sampling is a method where participants are chosen based on the ease of in-depth knowledge of a phenomenon, availability, accessibility, and willingness to participate in the research. The sample participants for this study comprises engineers, artisans, scientists, and project leaders, and exclude students, administrators, laboratory assistants, cleaners, safety officers, and facilities managers who also worked at the R & D centre. This is a cross-sectional study and was conducted once off over a specific timeframe, providing a snapshot of the Stage-Gate implementation within the institution at a particular point in time. The sample size for this study was determined by saturation plus two since it is a qualitative study.

In this study, data was collected through online interviews and recorded using a cell phone in adherence to the guidelines set forth by the POPI Act. The subsequent data analysis utilises methods of summation and thematic analysis, with an emphasis on discerning recurring patterns and themes within the data (Braun & Clarke, 2006:79). Thematic analysis commenced with the researcher conducting and recording interviews, and asking a set of predetermined questions.

After completing the interviews, the researcher meticulously read and interpreted the text data, subsequently transforming the data through coding and recording. The refined data was then closely scrutinised to identify emergent themes. Finally, these original themes were utilised to enhance the coding system, essentially forming a comprehensive list of all themes and codes that appeared within the data. The research strictly adhered to ethical research principles, which include ensuring informed consent from the participants, maintaining confidentiality, upholding research integrity, and ensuring beneficence (Akaranga & Makau 2016:102).

Lastly, the research data was stored securely, safeguarded against unauthorised access, use, disclosure, and loss. It is important to highlight that, once the study is finalised and the data is no longer required, it will be appropriately deleted and disposed from all sources of storage.

1.9. Layout of the study

This section describes the layout for the entire research project, thereby showing the link between the problem statement, objectives and research questions, literature review, methodology followed, results presentation and discussion, managerial implications and finally, the conclusion and recommendations.

Chapter 1: Introduction and background to the study

The study’s introduction is covered in this chapter, and it provides an indication of what the study is about and the expectations thereof. It gives the reader a background to the study as well as an overview by describing the aims, objectives, rationale, research questions, problem statement, and definitions of key concepts. The research design and methodology are also briefly explained in this chapter.

Chapter 2: Literature review

The goal of this chapter is to discuss the definitions, theories, and literature that already exist on significant and fundamental topics of the Stage-Gate approach as a project management tool. At this point, the researcher is able to synthesise the information to identify the gaps.

Chapter 3: Research design and methodology

This chapter describes the research plan and methods to be used for data collection. Here, the researcher gathers all the tools needed to execute the research, including ethical and regulatory documentation governing the topic under investigation.

Chapter 4: Interpretation and discussions of the results

The purpose of this chapter is to analyse the data acquired throughout the study project's interview sessions with various participants. At this point, collected data is interpreted and discussed thoroughly to present the findings.

Chapter 5: Conclusions and recommendations

This chapter provides answers to the research questions based on the findings presented. Furthermore, the recommendations and guidelines for the implementation of the Stage-Gate method will be provided based on the findings.

1.10. Chapter summary

This chapter contextualised the Stage-Gate method as an alternative project management tool for research and development (R&D) projects, focusing on its superiority over the traditional Waterfall approach. The chapter also highlighted the popularity of the Stage-Gate method in various industries, its effectiveness in addressing market and customer needs, and its integration of customer feedback and risk management. Moreover, this chapter delved into the problem statement, articulated the research aim and objectives, formulated research questions, outlined the scope of the study, and emphasised the significance of this in institutions of higher learning. Furthermore, a concise overview of the conceptual framework and methodology to followed was provided, indicating the systematic approach employed to attain the study’s objectives. The next chapter therefore provides a comprehensive overview and synthesis of existing research on research works’ alternative project management tools, gaps and challenges.

CHAPTER 2

LITERATURE REVIEW

2.1. Introduction

In the previous chapter, the contextualisation of the Stage-Gate method as an alternative project management tool for research and development (R&D) projects, focusing on its superiority over the traditional Waterfall approach, was developed. This chapter focuses on the review of literature. The primary objective of literature review is to expand researchers' knowledge on work done in this area of study by other researchers and what the outcome of their studies was. Furthermore, the literature review explores various constructs associated with the Stage-Gate method for the management of R&D projects. The aims were to provide a comprehensive understanding of what Stage-Gate entails, including its conceptual framework, key principles, and underlying processes. The practical applications of Stage-Gate within the context of managing research and development projects and/or new product development in various sectors of the economy. Within this context, the type of solutions that can be provided by the Stage-Gate method and successes thereof are discussed.

2.2. Challenges in managing R&D projects

According to Powers and Kerr (2009:2-5), research institutions, especially those in the academic environment, rarely follow a structured approach to managing research projects from conceptualisation to commercialisation. Palo-Oja *et al*. (2017:4) explain that very few research projects carried out in academic research institutions and developments centres as new innovations are turned into commercial products. This could be attributed to the lack of an appropriate project management approach that is structured to track the progress of product development accurately as well as identifying problems on time and resolving them before the product reaches the testing phase. The missing of deadlines, unclear deliverables, project delays, lack of accountability linked to leadership skills, and running non-feasible projects are some of the common challenges leading to project failures (Powers & Kerr, 2009:2-5).

Yaw Koi-Akrofi *et al*. (2019:38-39) further explain that R&D institutions generally rely on methods that conform to the conventional Waterfall approach, which is characterised by inflexibility, slowness, rigidity, and being monolithic. Furthermore, R&D projects are susceptible to budget overruns due to a comprehensive system test at the final stage of product development, as opposed to performing phased testing, argues Cervone (2010:18).

However, Charvat (2003:4), in an earlier study, argued that there is no single universally acceptable project management method that fits all projects and, as such, it is challenging to implement a generic method without alterations. Therefore, a project management method must allow flexibility and modifications to fit the strategies of the specific operations. The Stage-Gate method is one of the many project management tools that meets this criterion as it has been used for new product development in many industries (Edgett, 2015:1). However, a generic version of the Stage-Gate method cannot be applied without tailoring it to the specific project needs (Ettlie & Elsenbach, 2007:21,22).

2.3. Conceptual and theoretical underpinning

The Stage-Gate method was developed by Robert Cooper in the early 1990s, and it consists of a sequence of stages and gates, as shown in Figure 2-1 (Cooper,1990:46). Each stage is characterised by a defined set of research activities, while the gates serve as checkpoints where decisions are made, guided by predetermined criteria. The full five Stage-Gate method, shown in Figure 2-1, is specifically designed for large projects with high-risk potential (Cooper 2022:48). This method helps organisations to plan, manage, and execute projects efficiently by breaking them down into smaller and more manageable stages. Each stage described under the subheadings below has a checkpoint to ensure that the project is on track and that risks are effectively mitigated.

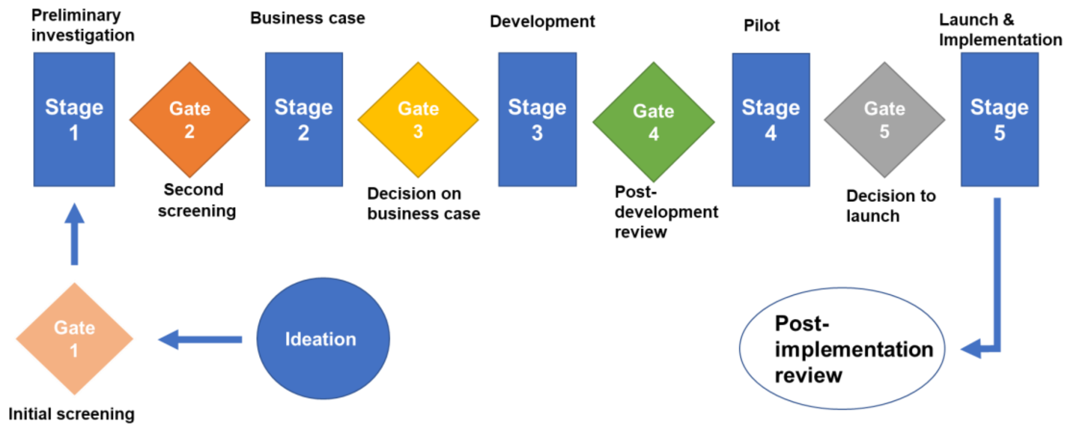


Figure 2-1: Full Stage-Gate for large and high risk projects

Source: Cooper,1990:46

2.3.1. Idea generation phase

The first step of the Stage Gate method is idea generation, which is a creative process of brainstorming and proposing new concepts (Cooper,1990:46; Cooper 2022:48). This also involves an extensive literature review, including intellectual property screening to determine the freedom to operate. The primary objective of idea generation is often to tackle a specific problem and develop effective solutions. This is basically the critical thinking of exploring new, creative, novel, and inventive approaches that bring fresh perspectives into play to solve problems. While not every idea may qualify as intellectual property, certain concepts may possess elements that necessitate protection. It becomes crucial to carefully evaluate the ideas' uniqueness and potential value to determine whether safeguarding them through intellectual property rights is necessary. Furthermore, the generated ideas are expected to extend their impact beyond individual realms and offer socioeconomic benefits. By striving to contribute positively to society's well-being, these ideas aim to foster advancements that enhance various aspects of people's lives, creating a better future for all. Since all ideas are not winning ideas, the evaluation results are submitted to Gate 1 for initial screening and this will determine whether ideas generated are novel and meant to address a particular societal problem (Cooper, 2006:26-27).

2.3.2. Conceptualisation phase

The second step is the preliminary investigation to assess the technical feasibility and market potential of the idea/concept at low cost and short time (Copper 1990:46; Cooper, 2006:26-27). Technical feasibility may also be assessed in the form of experimental proof-of-concept in a laboratory environment. This is a low-risk and low-cost investigation step that is evaluated in Gate 2 before major resources can be allocated to the project. In Gate 2, the technical requirements, markets, potential risks, and commercialisation paths are evaluated.

2.3.4. Businesses case development

The third step involves building a business case or concept by conducting an in-depth market analysis to determine customer preferences, market size, segments, and competition (Cooper, 2006:26-27). Financial assessments, including cost-benefit and sensitivity analyses, are carried out, and potential partners in the industry are identified. Gate 3 assesses whether the estimated operating and capital expenditures, revenue, and selling price meet the set criteria.

2.3.4. Execution phase

The fourth step entails prototype development, operational planning, and addressing legal issues, which will be submitted in Gate 4 for evaluation (Cooper, 2006:26-27). This gate ensures that the prototype is refined for scaling and that all legal and regulatory concerns are addressed. The fifth step involves pilot testing and field trials to validate the product in real-world conditions, followed by market testing and demonstrations for potential customers. In Gate 5, the product launching is decided. Once the operations and marketing plans have been formulated, evaluated, and granted approval, the production of units can commence. In the post-launch review, the project team disbands, and the product becomes part of the regular offerings. Performance data, including revenues, profits, losses, and costs, are used to evaluate the product’s success (Copper 1990:46).

The Stage-Gate method is known for guiding the innovation process and has evolved to include streamlined versions, namely Lite (three-step) and XPress (two-step) (see Figure 2-2) (Cooper, 2008:223). These simplified variants are crafted specifically to manage lower-risk and simpler projects, enabling quicker and more efficient progression through the development stages. Lower risk projects, which typically have well-defined parameters and predictable outcomes, might follow the Stage-Gate Lite or XPress paths (Figure 2-2). These streamlined versions of Stage-Gate are designed to facilitate quicker decision-making and implementation, reducing the time spent in the development process. As shown in Figure 2-2, the number of stages is reduced to speed up the process. Nevertheless, the methods in Figure 2-2 are not universally applicable, particularly for businesses engaged in exceptionally innovative ventures. For example, the standard or even streamlined Stage-Gate method may not be sufficient for advanced technology projects. These projects tend to be high-risk, span over longer durations, and have a high degree of uncertainty. Due to their unique nature, the projects necessitate a different approach to project management. In response, some companies have pioneered and adopted entirely different development processes. These are often more flexible, adaptable, and robust to accommodate the volatile nature of highly innovative projects (Cooper, 2006:26-27).

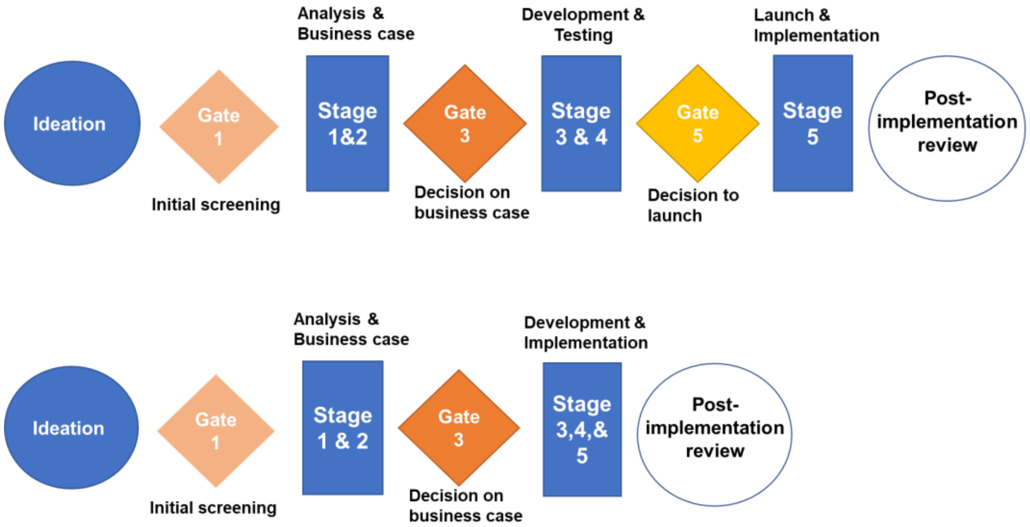


Figure 2-2: Stage-Gate Lite (top) and Stage-Gate XPress for low risk projects

Source: Cooper 2008:223

2.4. The functioning of Gates

Gates are decision points in a project where specific criteria, whether quantitative or qualitative, are used to determine the next course of action (Cooper & Edgett, 2012:5). There are four critical decisions that need to be made at each gate: Go (Pass), Kill, Hold, and Recycle. A *Go* decision indicates that the project is ready to advance to the next phase, whereas a *Kill* decision terminates the project due to a lack of potential or value (Cooper & Edgett, 2012:5). A *Hold* decision signifies that while the project has merit, it is not yet prepared to progress to the subsequent stage. Finally, a *Recycle* decision suggests that the project can be developed further if its scope undergoes specific adjustments. Gates consist of two distinct segments, as illustrated in Figure 2-3. The initial segment (represented by the left diamond) involves a conventional gate meeting where the project undergoes evaluation based on a fixed set of criteria, such as alignment with the organisation's strategy and leveraging its strengths (Cooper *et al.,* 2008:48). If the project meets these standards, the decision is *Pass*. Conversely, if the project fails to meet the criteria, a *Kill* decision is made (Cooper *et al.,* 2008:48). The project's impact on the overall portfolio value, balance, resource allocation, and strategic alignment must be assessed. If the project adds more value to the business than other ongoing projects, contributes to a balanced project mix, does not overburden limited resources, and aligns with strategic priorities, it becomes an active project. If not, the project is put on hold as it may not positively affect the portfolio at this time, though its potential may be realised later. Progressive companies integrate this two-part gating structure and periodic portfolio reviews into their new product development processes to enhance portfolio management.

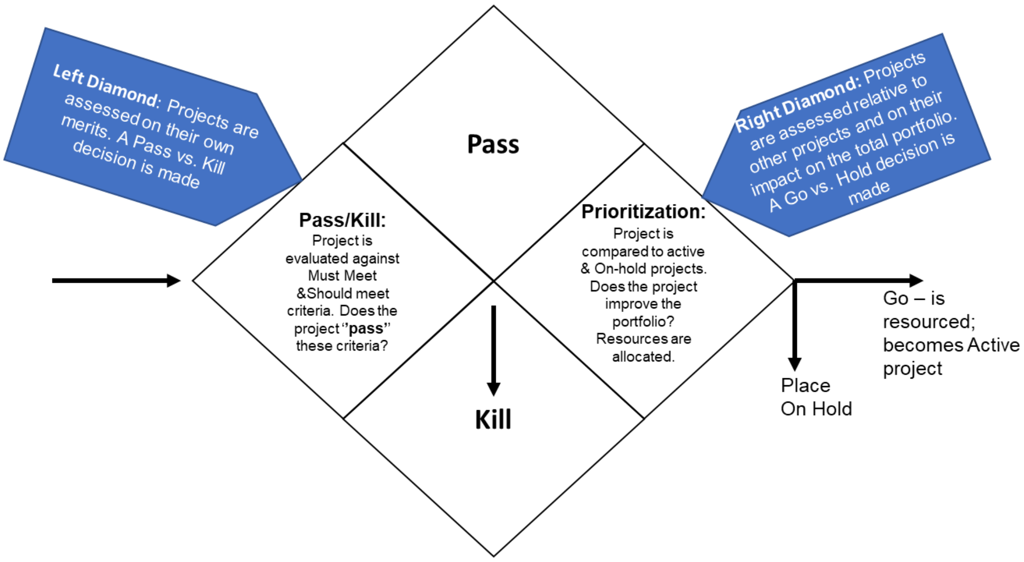


Figure 2-3: An illustration of the Gate decisions

Source: Cooper *et al*., 2008:48

2.5. The role of gatekeepers

Gatekeepers are usually senior personnel who play a crucial role in making final decisions and managing the gates within the Stage-Gate method. According to Cooper and Edgett (2012:5), gatekeepers are specifically assigned management team members responsible for making *go/kill* decisions at each gate. These individuals possess the knowledge, expertise, and authority to evaluate the progress and feasibility of a project at each stage. The gatekeepers may vary based on the project’s changing risk profile, as different skillsets and perspectives might be required to assess various aspects of a project (Cooper & Edgett, 2012:5,6). They are diligent in scheduling and attending gate meetings and make valuable, well-informed contributions to the decision-making process. Their involvement ensures that projects align with the organisation’s strategic objectives and available resources.

As already mentioned, gates serve as quality control checkpoints within the system, ensuring that appropriate projects are executed correctly and meet the established criteria (Cooper & Edgett, 2012:5). Effective gates are crucial for the success of a rapid and efficient product innovation process, as they maintain the integrity and efficacy of the system. They help organisations to minimise risks, optimise resource allocation, and eliminate underperforming projects earlier. Therefore, good gate-keeping practice is important for the effective implementation of the Stage-Gate method. This involves clear communication, well-defined criteria, and a structured decision-making process (Cooper & Edgett, 2012:5). By fostering a culture of accountability, transparency, and open dialogue, organisations can ensure that gatekeepers make informed and objective decisions, ultimately leading to a more successful and streamlined innovation process.

2.6. Advanced Stage-Gate method

The Stage-Gate method has been found to complement other project management approaches such as agile methodology. Cooper and Sommer (2016:167) proposed a hybrid approach that combines the flexibility and speed of agile development with the structure and discipline of the Stage-Gate process. The agile Stage-Gate hybrid method incorporates the concept of voice of the customer (VoC) within its framework (see Figure 2-4). By integrating VoC into the hybrid method, Cooper and Sommer’s approach ensures that customer requirements and feedback are continuously considered and incorporated into project decisions at each Stage Gate. This customer-centric approach helps to enhance customer satisfaction, optimise product or service offerings, and increase the likelihood of project success in the market. The authors suggested that this approach can improve the efficiency and effectiveness of new product development by reducing cycle time, increasing collaboration, and improving decision-making.

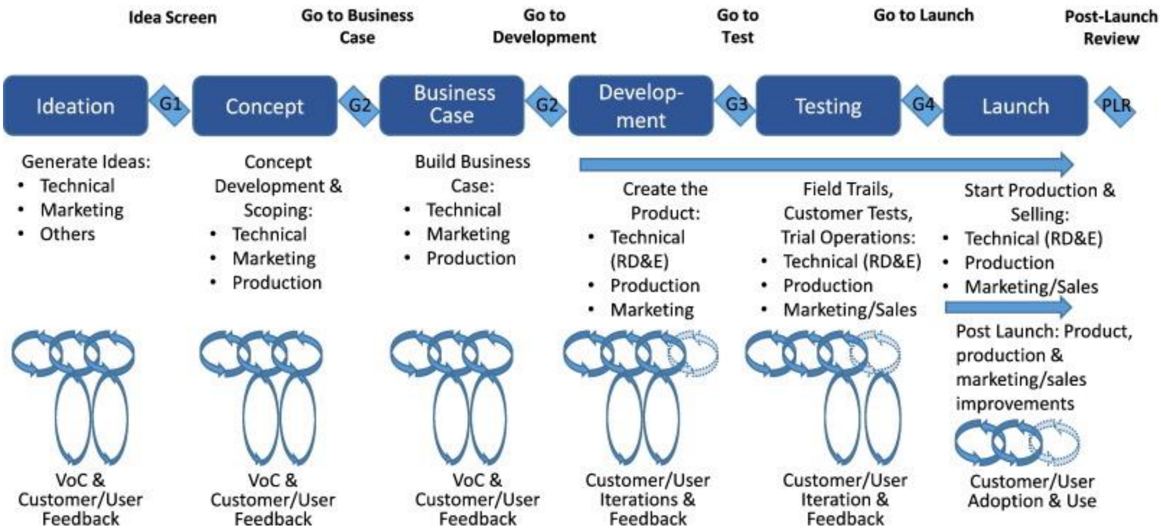


Figure 2-4: Agile Stage-Gate hybrid method

Source: Cooper and Sommer 2016:169

Moreover, a hybrid method combining the Stage-Gate and agile-scrum methods has been adopted by several companies to improve product development and project management (Eljayar & Busch, 2021:39). This is another example of modifying the method to fit the company-specific needs, leading to ambiguity regarding the structure, roles, and responsibilities. A qualitative survey of experienced individuals revealed similarities and differences in these aspects, dependent on the product and project type (Eljayar & Busch 2021:39). The method was found to improve team communication, performance, quality, and productivity (Eljayar & Busch 2021:39). According to Edwards *et al*. (2019:1), a hybrid method agile Stage-Gate improved the time to market, overall new product process, and success rate for the small-to-medium enterprises (SMEs). However, the agile methodology required adaptations to fit the SME context, and the test firms found novel solutions to address these challenges. Cooper (2008:213-214) provided an updated version of the Stage-Gate method, incorporating new concepts and practices such as portfolio management, open innovation, and lean startup. The author highlighted the importance of flexibility and adaptability in the process.

2.7. Advantages of the Stage-Gate method

Stage-Gate provides a structured framework for managing projects with defined deliverables and decision gates. The use of this approach offers several advantages, some of which are listed below.

a. The Stage-Gate process places a strong emphasis on market orientation in new product development by ensuring that customer needs are integrated into the project design (Cooper, 1990:48).
b. The Stage-Gate method serves as a quality control mechanism, as it enables early detection and resolution of issues before they escalate (Cooper, 1990:46).
c. Stage-Gate reduces the time to market process by breaking down projects into smaller stages with clear objectives and deliverables, which enables parallel workstreams, potentially leading to faster project completion (Cooper, 1990:48).
d. The Stage-Gate process enables companies to align their projects with their overall business strategy by providing a mechanism to review project relevance. It ensures that projects not aligned with the company's strategic goals are terminated (Sommer *et al*., 2015:39-40).
e. The Stage-Gate process offers enhanced quality, discipline, and overall performance compared to informal development processes (Sommer *et al*., 2015:41).

2.8. Disadvantages of the Stage-Gate method

Although the Stage-Gate process is widely used in project management and has many benefits, it is not without potential drawbacks, which may be due to poor implementation. Some of the disadvantages associated with this method are listed below.

a. Gate reviews typically involve senior-level managers who make the *Go/Kill* decisions, but they may not have a complete understanding of the fine details of the project (Cooper, 2008:218-219).
b. It may result in bureaucratic delays and slow decision-making due to the multiple reviews and approvals involved (Cooper, 2008:218-219).
c. The Stage-Gate process can be costly in terms of resources and time due to the extensive reviews and approvals required (2008:218-219).

2.9. Implementation of the Stage-Gate method

It is crucial to understand the essential requirements for a successful implementation of the Stage-Gate method, particularly for improving project outcomes. Cooper and Edgett (2012:43) conducted studies with 211 participating companies, identifying several key attributes necessary for implementing the Stage-Gate method successfully. Firstly, the method must be accessible and thoroughly documented, with operational-level descriptions and guidelines that are easy to understand and follow (Kotter, 2007:60-67). Secondly, project teams should be granted access to the essential resources required for success, while the organisational environment should foster support for research teams throughout product development, resource allocation, and market launch processes (Kotter, 2007:60-67). Thirdly, successful organisations indicated the implementation of compliance checks to verify that the process guidelines are adhered to and enforced, with consistent monitoring of the process' efficiency. Lastly, the Stage-Gate process is flexible and can be scaled according to the needs of different project types (Kotter, 2007:60-67). For instance, large projects with significant risk, such as major new product developments, may necessitate a complete five-stage process. Medium-sized projects with moderate risk, such as extensions, modifications, or improvements, can leverage the three-stage *XPress* process. Sales force and marketing requests with minimal impact on the business can employ the two-stage *Lite* process (Cooper, 2008:223).

The five Rs of resilience described by Hopkin (2014:254), i.e. robustness, redundancy, resourcefulness, rapidity, and reflexivity can be considered enablers to the successful implementation of the Stage-Gate process. By integrating these principles into the organisation, it can build resilience and ensure that the Stage-Gate process operates efficiently and effectively. For instance, the principles of robustness and redundancy can be applied to design the Stage-Gate process with backup plans, alternative resources, and multiple decision-making paths. Resourcefulness can be used to ensure that the organisation has the necessary resources and capabilities to implement the Stage-Gate process successfully. The rapidity principle can be leveraged to ensure that the Stage-Gate process is agile enough to respond to changes quickly. Lastly, reflexivity can be applied to enable continuous improvement of the Stage-Gate process and ensure its alignment with the organisation's objectives.

Therefore, the five Rs of resilience can serve as enablers to enhance the successful implementation of the Stage-Gate process.

2.10. Practical examples of Stage-Gate application

In this section, some of the real-world examples that have been successfully developed using the Stage-Gate process are briefly described. As mentioned earlier, Stage-Gate offers a high level of adaptability, allowing businesses and projects to tailor the framework according to their specific requirements. This flexibility has been embraced by several leading companies spanning various industries, including automotive, energy, IT, petrochemicals, and chemicals (Stage-Gate International, 2023). In Table 2-1, a concise overview of these industry giants and some highlights of the remarkable solutions they have achieved through their implementation of the customised Stage-Gate are provided. Examples of solutions are described below:

a. **Assessment of innovation performance**

Innovation performance assessment is vital for organisations, as it helps in understanding the effectiveness of innovation initiatives, identifying areas for improvement, and taking appropriate actions to increase innovation effectiveness (Schultz, 2019:539). As shown in Table 2.1, the majority of companies initiate their innovation journey by using performance gap assessments. This assists in pinpointing their most significant opportunities and ameliorating their innovation outcomes.

b. **Governance of R&D portfolio**

Triumph in innovation commences by making strategic choices across portfolios and projects, thereby enabling the execution of your product innovation and technology roadmap (Sommer *et al*., 2015:42). Portfolio governance programmes can be utilised to optimise the balance between innovation risks and returns, prioritise projects, and integrate this system with your project Gate-funding decisions.

c. **Development process for new products & services**

Stage-Gate new product development (NPD) programmes can be implemented to augment the success rates of new products and services while also merging effectively with your R&D portfolio governance process (Cooper & Edgett, 2006:11). In combination with agile software development frameworks, the Stage-Gate is an extremely useful tool for cross-functional teams (Stage-Gate International, 2023). It provides a clear structure that helps teams in defining, developing, and launching successful hybrid physical and digital solutions. By offering a systematic approach to project management, Stage-Gate allows for better planning, control, and quality of output. It encourages a focus on important tasks and improves resource allocation, all of which can lead to enhanced project success rates.

d. **Digital transformation**

Organisations burdened with managing R&D through numerous spreadsheets, documents, and disjointed software tools benefit significantly from digital transformation programmes (Stage-Gate International, 2023). This next-generation innovation management system offers substantial cost and time efficiencies by streamlining your R&D portfolio and product development procedures. It eliminates the dependence on spreadsheets and implements certified software, automating the entire process. This not only integrates with existing, disconnected software tools and data, but could potentially replace them, offering a more efficient and unified management solution.

Table 2-1: Solutions offered by Stage-Gate per industry type

Industry	Type of solutions	Client examples
Automotive & transportation	• Innovation performance assessment • R&D portfolio governance • New product & service development process • Digital transformation	• MAHLE Industries • Wabash National Corp • Ryder Canada • IAC Group Europe
Energy, oil & gas	• Innovation performance assessment • Portfolio strategy • New product & service development framework • Benchmarking and next-gen performance roadmap	• ExxonMobil • Woodside Energy • National Oil Well Varco • Haliburton
Chemicals and process industries	• New product & service development framework • R&D portfolio governance • Innovation performance assessment	• DuPont • BASF • Bayer • Eastman Chemical
Software & digital products	• Innovation performance assessment • R&D portfolio governance • New product & service development process • Digital transformation	• Hitachi Data Systems • Bentley Systems • Logitech Inc.

Source: Stage-Gate International, 2023

2.11. Critical success factors

To optimise the likelihood of success when employing the Stage-Gate method, various key success elements warrant careful attention. These elements, or critical success factors, are the backbone of any successful application of the Stage-Gate method. Incorporating these factors into the project management approach enables organisations to substantially bolster their potential for successful project delivery. Several critical success factors to be considered are discussed below:

a. **Cross-functional teams**

According to Bhuyain (2011:750), a pivotal success factor in the application of the Stage-Gate process relies on the extent of functional integration. Essentially, this speaks to the cohesiveness and collaborative effectiveness of multidisciplinary teams in aligning their efforts towards a shared objective (Bhuyain, 2011:750). Therefore, expertise of individuals from various departments such as R&D, marketing, finance, and manufacturing is crucial for successful product development. Cross-functional teams bring a diversity of perspectives to the project, ensuring that the project is viable from all angles. For instance, while the R&D team ensures technical feasibility, the marketing team can assess market demand. This comprehensive approach to project management can help pre-emptively identify and mitigate potential issues (Edgett, 2015:1-2).

b. **Senior management involvement**

Executive involvement is essential as their strategic vision guides project decisions. They also have the authority to allocate resources as necessary, making their involvement crucial for the progress and success of the project (Edgett, 2015:4). They can also remove roadblocks that might hinder the project, streamline processes, and ensure alignment with broader organisational goals (Cooper, 1990:46).

c. **Clear objectives and goals**

Setting clearly defined, achievable goals for each stage helps focus the team's efforts and reduces ambiguity. These goals can be based on various criteria such as cost, time, quality, or technical requirements. They also serve as a metric for success, allowing for objective assessment of the project's progress and outcome (Edgett, 2015:1-2).

d. **Customer-driven focus**

To achieve success in the market, it is essential for products to effectively tackle the challenges and issues encountered by customers or potential customers (Edgett, 2015:1-2). This means identifying their pain points, desires, and unmet needs, and developing solutions that directly address those specific concerns. By doing so, a product can position itself as a valuable and indispensable tool for its target audience. One crucial aspect of ensuring that a product meets customer expectations and stands out from competitors is the gathering and analysis of customer feedback. This feedback serves as a valuable source of information, providing insights into the strengths and weaknesses of a product. Through systematic data collection methods such as surveys, interviews, and user testing, organisations can gain a deeper understanding of how their product is perceived and utilised by customers.

e. **Effective gatekeeping**

Gatekeepers are essential in the Stage-Gate process as they have the power to move projects forward or halt them based on thorough analyses (Edgett, 2015:1-2). They should be unbiased and capable of making difficult decisions, including killing projects that do not align with strategic objectives or are not showing sufficient promise. This gatekeeping role ensures that only projects with high potential are pursued (Edgett, 2015:1-2)

f. **Flexible and adaptable process**

While the Stage-Gate process provides a structured approach, it should not be overly rigid (Cooper, 2008:215-218). It should have the flexibility to adapt to changing project needs, market conditions, and technological advancements (Cooper, 2008:215-218). This adaptability might include modifying the number of gates, the criteria used for evaluation, or the overall process based on lessons learned from previous projects (Cooper & Kleinschmidt, 2007:57).

g. **Post-project reviews**

These reviews, sometimes called *post-mortems*, involve analysing completed projects to identify what worked, what did not, and why. This iterative learning process helps teams to improve project management, make better decisions in future projects, and enhance the overall Stage-Gate process (Cooper, 2017:50).

h. **Adequate resources**

Sufficient resources are the backbone of a project’s success. These resources extend beyond just financial backing and also encompass human resources, physical resources, technological resources, and time (Edgett, 2015:2; Florén *et al.,* 2018:417-418). For example, projects require skilled personnel who can manage and execute the tasks involved. Physical resources such as workspace and equipment may be necessary, and technological resources could include software, hardware, or technical knowledge necessary for the project (Bhuyain, 2011:750-755). Additionally, ample time must be allocated to each stage of the project to ensure thoroughness without rushing through essential steps. Sufficient budget allocation is crucial for facilitating all these resources. Management plays a key role in guaranteeing that teams are equipped with all they need to realise their goals, thereby increasing the likelihood of project success (Bhuyain, 2011:750-755).

i. **Portfolio management**

The idea behind portfolio management within the context of the Stage-Gate process is that not all projects carry the same level of risk or potential for returns. Therefore, businesses need to manage their projects much like an investment portfolio, balancing riskier, high-reward projects with safer, lower-reward ones (Cooper & Kleinschmidt, 2007:57). This way, they can optimise resource allocation, align projects with strategic objectives, and ensure a healthy pipeline of new products. It provides a holistic view of all projects, enabling decision-makers to make informed choices about which projects to continue, add, or terminate (Cooper, 1990:46).

j. **Quality of execution**

Each stage of the Stage-Gate process demands meticulous execution. For instance, market analysis should accurately assess customer needs, competitive landscape, and market trends (Cooper & Kleinschmidt, 2007:57; Ismail *et al.*, 2012:9449). Technical activities should ensure the product is feasible, reliable, and meets all required specifications. Business analysis should validate that the product will provide adequate returns and align with the organisation’s strategic objectives. Poor execution at any stage could lead to flawed insights or errors, which could, in turn, impact the final product’s quality or commercial success. Therefore, the importance of attention to detail and quality control in each stage cannot be overstated (Bhuyain, 2011:750-755).

2.12. Misconceptions around the Stage-Gate method

The Stage-Gate process is often misunderstood, leading to various myths (Cooper, 2008:215-218). It is not merely a functional, phased-review process, but rather a cross-functional approach that fosters collaboration across various departments, ensuring a holistic view of project progress myths (Cooper, 2008:215-218). It is also not a linear system; while it progresses in stages, feedback and iterative learning allow for adjustments and revisits, making it a dynamic and cyclical process. The Stage-Gate process is not merely a project control mechanism, but a strategic tool that aligns product development with the company’s broader strategic goals.

Contrary to the belief of some, the Stage-Gate process is not a rigid, lock-step procedure. It is flexible, adaptable, and can be customised to the specific needs of each project or organisation. It is also not an outdated, stagnant system (Cooper, 2008:215-218). The principles of Stage-Gate have evolved over time, with newer versions incorporating aspects of agility and lean methodologies.

Furthermore, the Stage-Gate process is not a bureaucratic system. While it does provide structure, its essence lies in enabling effective decision-making and ensuring the efficient use of resources. Also, it is not solely a back-end or product delivery process. The Stage-Gate process spans the entire product development cycle, from ideation to post-launch review.

Lastly, the Stage-Gate process is not merely a data entry scheme. Although data collection and documentation are a part of the process, it is more about information analysis, interpretation, and strategic decision-making (Cooper, 2008:215-218). The goal is to reduce uncertainty, manage risks, and increase the odds of product success in the market. Cooper also asserts that it is important not to conflate the 21st-century Stage-Gate process with the traditional phased review processes that were prevalent between the 1960s and 1980s, as the modern approach has significantly evolved and improved since then (Cooper, 2008:215-218).

2.13. Chapter summary

There is limited information that specifically elaborates on the type of methods applied by academic institutions in managing R&D projects. As indicated by some authors, academic institutions seem to follow Waterfall-like types of project management approaches, which are deemed to be rigid and inefficient by various stakeholders. The challenges associated with unclear project management approaches have been identified. It was found that the proposed Stage-Gate method has been successfully implemented by various sectors, including automotive, IT, petrochemicals and chemicals. However, limited information exists on the application of Stage-Gate in academic institutions and for research purposes. Therefore, aligning this method with academic research could be beneficial because, lately, institutions have been mandated to commercialise products. Stage-Gate must be tailored to fit the specific requirements of the project and, for it to be successfully implemented, all necessary resources must be adequately allocated and managed.

CHAPTER 3

RESEARCH METHODOLOGY

3.1. Introduction

In the preceding chapter, the researcher conducted a literature review to gain a broader understanding of the work undertaken by other researchers and the results of their investigations. The conceptual framework of the Stage-Gate method, key principles, and the underlying processes associated with this method were discussed. In this chapter, the researcher provides a description of the methodological approach applicable to this study, which includes philosophical assumptions underpinning this study, research design and approach, data collection, and the method of analysis. The research design applied in this study is qualitative exploratory-descriptive research. As explained by Polit and Beck (2017:40), this design allows the researcher to explore and discuss a research problem from a comprehensive perspective. Furthermore, the qualitative exploratory-descriptive research enabled the researchers to explore the challenges associated with R&D projects under investigation. Based on the experiences, opinions and views of the employees, the researchers will be able to determine and organise constructs in relation to Stage-Gate method implementation. A descriptive research design was found appropriate for this study because it provides a detailed, comprehensive, and practical understanding of how the R&D projects are conducted in practice.

Social scientists define a research design in different ways. According to Zikmund and Babin (2016:116), a research design is a strategy for outlining the methods and procedures for gathering and evaluating the required information. However, MacMillan and Schumacher (2001:166) view it as a study design that gives the logical underpinning of decisions linked with data collection, processing, and analysis to answer the research questions. Nonetheless, a research design ensures that the study is pertinent to the problem in question (Malhotra, 2010:182), while the methodology is defined as the theory that provides guidelines on how a specific research or inquiry should be conducted (Schwardt, 2007:195).

These definitions put emphasis on a theory-based and structured approach for gathering appropriate information needed to answer research questions for a specific study. Research design is categorised as correlative, descriptive, causal-comparative and experimentative (Bloomberg & Volpe, 2016:42; Zikmund & Babin 2016:116).

3.2. Empirical study

This study is based on the use of primary data generated through interaction with human participants. According to Joop and Hennie (2005:593), primary data is the first-hand or original data gathered by the researcher for the investigation of the topic in question. This study explored the implementation of the Stage-Gate method in a research centre hosted by a South African higher learning institution by applying an empirical investigation. To achieve this objective, primary data was collected through interviews. The research design involves determining various methodological components, including the research paradigm, research approach, methodological choice, methodological strategy, time horizon, data collection techniques, and data analysis techniques. By considering these methodological components, the researcher collected and analysed primary data through an empirical investigation. This provided insights into the implementation of the Stage-Gate method in a research centre affiliated with a South African higher learning institution.

3.2.1. Research philosophy

The epistemological philosophy serves as the foundation of this study. Epistemology is a branch of philosophy that deals with the study of knowledge, belief, and justification (Maarouf, 2019:8; Yulianto, 2021:159). It examines the nature of knowledge and how we acquire knowledge, as well as the limits of knowledge and the criteria for determining what counts as knowledge. Ontology, on the other hand, is the study of the nature of being, existence, and reality. It examines questions about what entities exist and how they relate to each other (Maarouf, 2019:6; Yulianto, 2021:158). Axiology is the study of values and value judgements, examining questions about what is good, valuable, or desirable (Maarouf, 2019:9; Yulianto, 2021:160).

When exploring the implementation of Stage-Gate, epistemology is found as the most appropriate among the three branches of philosophy. This is because epistemology is concerned with the nature and limits of knowledge, which is essential for understanding how Stage-Gate works and how it can be improved. Epistemology assisted in examining questions about how we know what we know about Stage-Gate, what kind of knowledge is required to implement it successfully, and what criteria we can use to determine whether it is effective. Ontology and axiology may also be relevant in exploring the implementation of Stage-Gate, but are less directly related to the questions that need to be addressed. For example, ontology could help us understand the nature of the processes involved in Stage-Gate, but it does not directly address the question of how we know that these processes are effective. Axiology could help us determine what values are important in implementing Stage-Gate, but it does not directly address the question of how we know whether the implementation is successful or not.

Therefore, given the specific objectives of this research, an interpretive research paradigm and a qualitative approach are adopted. This enabled the researcher to explore the subjective experiences of participants and to gain a deeper understanding of the research topic.

3.2.2. Research approach

The methodological approach for this research is underpinned by an inductive approach. Inductive research is conducted under the interpretive research paradigm and entails creating a novel theory through the observation of reality and gathering primary data without considering pre-existing theories (Saunders *et al*., 2016:74). Moreover, inductive research involves formulating theories based on observations and data, whereas deductive research is positivistic, and it involves testing hypotheses using data and observations (Zalaghi & Khazaei, 2016:24; Saunders *et al*., 2016:74). Therefore, inductive research is found better suited for this study than a deductive approach for several reasons. Firstly, Stage-Gate is a complex process that involves multiple factors such as decision-making, resource allocation, risk management, and innovation management. These factors may interact in unpredictable ways, making it difficult to formulate a clear hypothesis in advance. In this case, an inductive approach allows researchers to explore the complex interactions and identify patterns and themes that emerge from the data.

Secondly, the implementation of Stage-Gate may vary across different industries, organisations, and contexts. A deductive approach assumes that the same hypothesis or theory will apply across all contexts, which may not be valid in this case. An inductive approach allows researchers to explore the implementation of Stage-Gate within different contexts and generate theories that are specific to each context.

3.2.3. Methodological choice

In this study, the mono-method qualitative study was found to be the most appropriate methodological option, considering the nature and objectives of this study. The exploratory nature of the research on the implementation of Stage-Gate and the need for in-depth insights and experiences through interviews made the qualitative method more suitable than the quantitative method. The methodological choice specifies whether quantitative, qualitative or a combination of both methodologies will be used for a particular study of interest. Quantitative methods, such as surveys and experiments, are not appropriate for this study, but more suited to testing hypotheses, measuring outcomes, and generalising results across a larger population (Wiid & Diggines, 2013:860).

Moreover, quantitative research is linked to the positivistic research paradigm, and its primary goal is to investigate hypothesised correlations between two or more variables using numerical data obtained from large samples and statistical analyses. Qualitative research is linked with the interpretivism research paradigm and concentrates on the subjective perspectives and beliefs of a small sample (Wiid & Diggines, 2013:85). In this regard, it is feasible to gain a deeper understanding of the topic under investigation and develop a theory based on the detailed information gathered (Wiid & Diggines, 2013:87). The qualitative method enables researchers to gather rich and detailed data on the implementation of Stage-Gate, to explore the complexities of the process, and to generate new insights and theories.

3.2.4. Data collection strategy

The data collection strategy that is applied to this study is semi-structured interviews. This is a valuable strategy for exploring the implementation of Stage-Gate because it provided a flexible and personalised approach to exploring the research question. The interviewer was able to explore areas of interest in more depth while still providing a structured framework for the interview. The data collection strategy, must be determined once the research paradigm, approach, and choice have been decided (Bryman & Bell, 2015:100). This can be carried out by performing experiments, surveys, case studies, action research and grounded theory, depending on the objectives of the investigation. Regarding qualitative research, which is the methodological choice in this study, the focus was on describing the beliefs and experiences of participants, and therefore open-ended questions were asked. The data collection tools for qualitative research include semi-structured methods such as in-depth interviews, focus groups and observations of a participant to collect descriptive data (Jamshed, 2014:87).

3.2.5. Time horizon

In this study, a cross-sectional method was followed, and the investigation took place over a single period in the short term. This method was chosen due to its cost-effectiveness and efficiency, especially for researchers who have constraints in terms of their resources and time, which was the prevailing situation during that period. Therefore, this study provided the current state of the subject matter and it does not provide information on changes over time, and any trends or developments that might occur. Resource include provision of the data bundles for all participants and the researcher to conduct online interviews. Both the researcher and participants limited time, due to availability, scheduling and study deadlines. Hence, it was not be feasible to conduct longitudinal studies. The time horizon defines the timeframe in which the research is to be carried out (Melnikovas, 2018:34). Cross-sectional studies are conducted in the short term and are used to assess data collected from research participants at a specific point in time (Bryman & Bell, 2011:53). Conversely, longitudinal is the frequent collection of data over a lengthy period in which participants are interviewed on several occasions, for detailed comparisons (Collis & Hussey, 2014:64).

3.2.6. Study population and sampling

The population of this study included all employees of a research centre that is hosted by the North-West University, Potchefstroom Campus, South Africa. This population is estimated at 50. The population at the research centre is dynamic as some employees embark on international research visits, new hires, resignations and ending of short-term contracts. This fluidity makes maintaining an up-to-date, exact database challenging, and thus an estimate is used for practicality. The students and laboratory assistants were excluded from the sample, as mentioned in the exclusion criteria below. This is to avoid the risk of conflict of interest or undue influence because of the hierarchical relationship with participants. The sampling method applied to this study is a non-probability technique of convenience sampling. This method is the quickest way of gathering data and it relies on the availability and willingness of participants to participate, rather than using a random selection process. To ensure efficient and meaningful data collection, the researcher started by interviewing eight participants and applied the concept of information power. This is because information power helps researchers to determine the sample size needed to achieve data saturation and meaningful analysis of data.

Although different authors have different views about the description of population and sample size determination in a qualitative research study, Banerjee and Chaudhury (2010:61) described a population as a complete set of people with similar characteristics in which the researcher is interested to study, while Polit and Beck (2014:5) describe the population as the entire element that the researcher intends to study. Moreover, Mohajan (2018:23) describes the study population as a fraction of the population that the researcher is interested in studying. However, Strüwig and Stead (2013:116) defined a population as a total set of individuals, events, objects, or elements of interest in a particular study.

A sample, according to Salkind (2010:1109), is a portion of the population that is chosen to represent the total population of a study. Convenience sampling is a non-probability sampling technique where a researcher selects participants based on set out criteria determined by availability, accessibility and willingness of participants to participate (Etikan *et al*., 2016:2) in a study. The abovementioned method was utilised in this study because it was not possible to interview all employees of the research centre in question. This was because of the effect of time constraints, as well as a common reality of individuals not interested and reluctant to participate. Therefore, this study focused on the participants to whom the researcher has the most convenient access. The inclusion criteria of the participants defined the characteristics of people included in the research project (Hornberger & Rangu, 2020:2).

In this study, a sample of participants included engineers, artisans, scientists and project leaders who are selected from the population of employees working for the research centre. The exclusion criteria describe the attributes of individuals who will not be taking part in the study (Hornberger & Rangu 2020:2). Therefore, students, administrators, laboratory assistants, cleaners, safety officers and facilities managers were excluded as they are support staff and are not involved in the project activities (core business of the research centre). It must be noted that the researcher has full access to the participants because he is a full-time employee of the research centre where the study will take place.

The sample size is often vague and a matter of controversy among many researchers (Saunders *et al*., 2019:315; Cooper & Schindler, 2014:349; Bryman *et al.*, 2014:176). Many researchers suggest the collection of data until saturation is reached, which means that interviewing more participants does not yield any new information for the study, according to Saunders *et al.* (2019:315). However, it is not clear how data saturation is assessed. The concept of information power was proposed by Malterud *et al*. (2016:1753), as a method of selecting the appropriate sample size. According to the concept of information power, the more relevant and rich content the sample holds, the fewer participants are required and vice versa.

3.2.7. Designing the measuring instrument

In this study, the researcher utilised a semi-structured interview, and this instrument enabled the collection of qualitative open-ended data from participants. This particular instrument is selected because the interviewer has a general outline of the topics to be covered, but can also deviate from the script or interview guide to explore unexpected or interesting responses from the interviewee. Data collection instruments commonly used in qualitative research include individual interviews, focus groups, and direct observations (Bryman *et al*., 2014:209). This study is based on raw data received from the narratives of the participants. In this case, the researcher has solely relied on participants' willingness in sharing their experiences, which subsequently contributed to the research topic. Furthermore, the semi-structured interviews assisted the independent research consultant to engage on a deeper level and explore the participant's ideas, feelings, and opinions about a specific subject (DeJonckheere & Vaughn, 2019:1). Since this study is based on a qualitative method, which included online interviews, an interview guide was developed based on the core themes or constructs.

3.2.8. Researcher's interaction with participants

The participants that took part in this study were researchers working for the R&D centre under investigation, and therefore an independent research consultant conducted interviews to avoid any potential conflict of interest and for the participants to feel free in voicing their opinions. The independent research consultant was provided with a group email address, as non-identifying criteria of communicating with all staff-members of the research centre. Furthermore, the content of the recruitment email also used the non-identifying criteria to identify potential participants, based on their job title and area of expertise. This was done to avoid using personal information such as their names, addresses, or phone numbers and to interact with participants in a way that is compliant with the POPI Act. The recruitment email informed the participants about the research project, the purpose of the interview, and the expected duration of the interview. The individuals who were interested in participating replied with their personal emails and this enabled the independent research consultant to engage further. Once the individual had agreed to participate, the independent research consultant and the researcher scheduled a mutually convenient time and location for the interview. The researcher also provided necessary instructions or materials (e.g. consent letter) needed to prepare for the interview. A few days before the interview, a confirmation message was sent to each participant to ensure that they are still available and to remind them of the interview details.

3.2.9. Collection of data

The method of data collection used in this study was in the form of recorded online interviews. This is because interviews enable the independent research consultant researcher to ask open-ended questions as well as probing to gain a deeper understanding regarding the implementation of the Stage-Gate process. Furthermore, this approach assisted in identifying bottlenecks, challenges, and opportunities for improvement in the current process. Interviews are meant to collect qualitative data, which can provide rich insights into the perceptions and experiences of those participants involved in the projects. Data collection can be defined as a systematic process of acquiring information to address research objectives. As already mentioned, interviews are the most utilised instrument in qualitative research. An independent research consultant executed interviews using an online Zoom platform, because it was more convenient for the participant. It must be noted that both the independent research consultant and the researcher kept the identity of the participants confidential and also complied with the POPI Act in respect of prospective participant contact details by meeting the minimal standards. A pilot study was not feasible due to the constraints of time and this is a small-scale study without complex ethical considerations and logistical arrangements.

Since the participants are colleagues of the researcher, an independent research consultant was recruited to conduct the interviews. The interview began with the independent research consultant introducing himself, thanking the participant for taking part in the interview, describing the goal of the study, and requesting their consent to record and take notes.

The participants were reminded by the independent research consultant that taking part in this study is completely voluntary and that they are free to withdraw at any time. The participants were also informed that the data collected will be kept confidential, used only for this study and that their anonymity is preserved (Bryman & Bell, 2011:130). After this disclaimer, the interview began with a predefined list of themes, ideally with pertinent questions to guide the conversation. Additionally, the independent research consultant employed probing to help participants elaborate on the subject further, enabling the acquisition of valuable data. Lastly, the recordings were manually transcribed by the researcher to produce a readable document.

3.2.10. Data analysis

A qualitative research method is applied in this study because a more in-depth and holistic understanding of the implementation of the Stage-Gate method can be provided. Saunders *et al.* (2019:640) provided an overview of three key techniques that are commonly used in analysing qualitative data, which are the summation method, content analysis method, and thematic analysis method. In this work, summation and thematic analysis are used to analyse this type of qualitative data because these methods focus on identifying themes and patterns in the data. Moreover, Saunders *et al.* (2019:640) explain that, in qualitative research, data collection and analysis are interconnected activities. One technique employed by researchers for data analysis is thematic analysis, which involves coding qualitative data to identify recurring patterns and themes related to the research questions (Saunders *et al.,* 2019:651). Thematic analysis is a structured and adaptable method that provides researchers with an approach to analyse data effectively. Braun and Clarke (2006:79) define thematic analysis as a qualitative data analysis approach that involves identifying, evaluating, and reporting on recurring patterns. The technique requires interpretation in the processes of choosing codes and generating themes, making it a data description approach. According to Saunders *et al.* (2019:652), there are four aspects of thematic analysis: familiarising with the data, coding, discovering themes and detecting links, and refining themes and testing propositions. Overall, thematic analysis is a crucial method for analysing qualitative data in a structured and effective manner.

According to Braun and Clarke (2006:79), thematic analysis comprises six steps, as indicated in Figure 3-1: data familiarisation, code generation, theme search, theme revision, theme definition and producing a report. Data familiarisation is the process of becoming acquainted with data gathered during interview sessions (Kiger & Varpio, 2020:4). This includes transcribing of data and reading the data to identify initial ideas. Code generation is identifying the most interesting features of the dada and coding in a systematic way throughout the entire dataset (Braun & Clarke 2006:79), while searching for themes refers to coding data into prospective topics and collecting all data relevant to each potential theme. Reviewing of themes entails the evaluation to determine whether the themes function in connection to the coded extracts and the complete dataset, followed by creating a thematic 'map' of the analysis (Salleh *et al*., 2017:1317). The definition of the themes step entails continuous analysis to fine-tune the specifications of each theme as well as the prior analysis, resulting in unambiguous definitions and names for each theme, producing of the report that deals with the final analysis and linking this with the research topic and literature and finally producing a report. Figure 3-1 shows some illustration of thematic analysis (Khokhar *et al*., 2020:426). In this work, the researcher employed a qualitative data analysis software, known as ATLAS.ti, to perform thematic analysis. ATLAS.ti is a qualitative research tool that can be utilised for coding and analysing transcripts and field notes, making literature reviews, developing network diagrams, and formulating data visualisation concepts. Figure 3-1 shows a flow chart of thematic analysis concept.

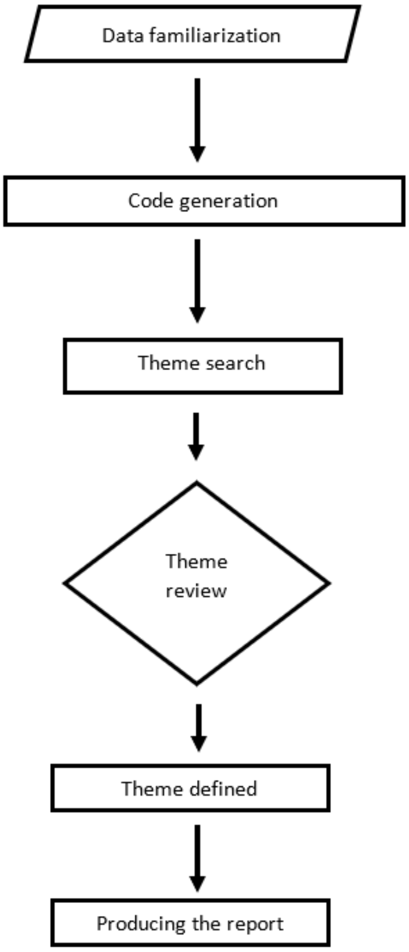


Figure 3-1: Flow chart for thematic analysis

Source: Khokhar *et al*., 2020:426

3.2.11. Trustworthiness

Trustworthiness in qualitative research enhances the comprehension and interpretation of study findings and enables people to have faith in the quality of the research (Daniel, 2019:119). Credibility, authenticity, dependability, and confirmability are the four qualities of trustworthiness in qualitative research (Bryman *et al.*, 2014:44). The transcribed recordings were validated by the researcher with each participant to ensure that the results are interpreted accurately. In this study, trustworthiness was preserved based on the qualities explained below:

Credibility: In order to ensure credibility in this study, independent coding was done during data analysis to eliminate data interference by the researcher based on his preconceived expectations (Connelly, 2016:435).

Confirmability: A peer-debriefing was done to ensure confirmability (Creswell, 2014:251; Ary *et al*., 2014:442)

Dependability: This was done for the purpose of ensuring the replicability of the findings in this qualitative study within the same cohort of participants. Therefore, the study methods are thoroughly described, encompassing a detailed account of the data collection process. According to Connelly (2016:435), the participants must be informed about the study area, population, sampling techniques, data collection process and data analysis techniques. Participants were also given the opportunity to comment on the research findings.

Authenticity: The voice recordings and transcribed data were repeatedly read and listened to, in order to ensure that the views of the participants are fully understood.

3.3. Ethical considerations

The term *ethics* within the context of research refers to moral principles that guide your conduct toward the rights of individuals who participate in or are impacted by the research process. In order to prevent damaging the relationship between the parties involved, it is appropriate to guarantee that the research process is carried out morally and that sensitive results are handled and disseminated in a delicate manner (Akaranga & Makau 2016:102). To ensure compliance with the university's ethical clearance, the proposal for this study was submitted to the relevant ethics committee for review. The study is approved and the ethics number was provided, see Appendix F. Furthermore, the researcher adhered to the approved proposal and ethical standards such as maintaining participant confidentiality, and handling data responsibly. Four ethical research principles deemed to be relevant will be considered in this study, including informed consent, confidentiality, research integrity and beneficence.

3.3.1. Informed consent

Informed consent is an ethical and legal prerequisite when conducting research that involves human participants (Nijhawan *et al*., 2013:134). According to Nijhawan *et al*. (2013:134), informed consent entails giving the targeted participants enough information to allow them to decide whether to participate in the study or decline the invitation to partake. Participants should participate in a study voluntarily and are free to withdraw from the interview session at any time. Therefore, a consent form with these details was provided to each participant prior the interviews.

3.3.2. Confidentiality

The right of privacy of the participants is ensured by preserving their anonymity, meaning collecting pictures, names and identity numbers is prohibited in this study. Therefore, participants were reminded not to provide their personal information.

3.3.3. Research integrity

In order to avoid plagiarism and its consequences, secondary data included in the study is properly cited. A researcher may have a tendency or a temptation to manipulate or withhold important information. Other academics and independent statisticians were involved throughout the research process to ensure integrity.

3.3.4. Beneficence

The well-being of the study participant is a priority for researchers, and the benefits of the research should exceed the risks (Weinbaum, 2018:10). According to Weinbaum, (2018:10), the benefits of participating in the study must be clearly communicated by the researcher to the participants. Throughout the research process, the researcher informed the participants that the research study is not intended for the researcher's financial benefit, but it is for academic purposes. This was to ensure that participants do not feel exploited. The participants were also informed that the findings are available to them, upon request, from the North-West University.

3.4. Data management

The following is an outline of the steps that were taken to store research data in a manner that safeguards it against unauthorised access, use, disclosure and loss.

- The access to research data (recordings, transcriptions, results and other relevant information) was limited to the researchers involved in the work. This was done by using passwords, access control lists, or other security measures to limit access to the data.

- Research data was stored and regularly backed up on secure servers, hard drives and computers that are protected from unauthorised access by using passwords and safe storage.
- Secure methods such as encrypted email or secure file transfer protocols were used when communicating research data.
- After completion of the research the data was carefully disposed by destroying physical paper records and securely erasing digital data.

3.5. Chapter summary

The chapter presented a qualitative research methodology, grounded in the interpretivist paradigm, which was employed to address the gaps in the application of the Stage-Gate method within an academic research setting. The study employs primary data collected via recorded interviews with key individuals involved in academic research projects, applying convenience sampling. Data analysis utilised summation and thematic analysis to uncover patterns and themes. Adherence to ethical principles and robust data management practices ensures the integrity and security of the data. The following chapter presents the results and discussion.

CHAPTER 4

FINDINGS AND DISCUSSION

4.1. Introduction

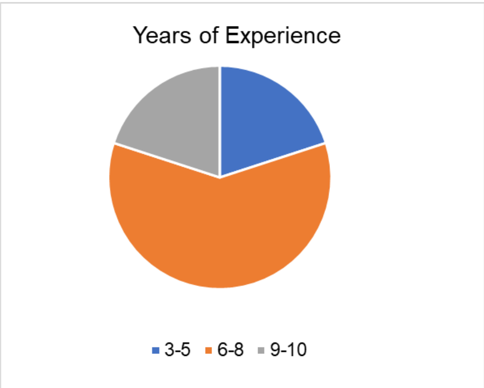
In the previous chapter, the researcher provided a detailed description of the methodological approach used in this study. This includes, but is not limited to the philosophical assumptions underpinning this study, research design and approach, data collection, and the description of thematic analysis steps. In this chapter, the findings are presented, interpreted and discussed based on the data gathered following the research methodology and design presented in the previous chapter. The participants interviewed in this study were recruited through convenience sampling based on their roles, level of experience within the research centre as well as their willingness and availability to partake in this study.

4.2. Data analysis

Data analysis in qualitative research follows a set of stages for segmenting and interpretation to understand the meaning of the transcriptions collected from the participants (Creswell, 2014:246). The data acquired from participants via interviews using the Zoom platform was analysed using open coding. The steps followed include transcribing interviews, data familiarisation, generating initial codes, organising codes, theme searching across dataset, and reviewing and refining themes. The aim was to determine participants' original interpretations based on the questions asked during the interview. Emerging themes were based on topics that consistently arose from the comments of participants during the interview sessions. The themes and subthemes were verified against participant replies to ensure an accurate representation of participants' experiences. To facilitate the coding process and to ensure that participants' identities are not traced, the following labels were used as a form of their identification: BFG 1, BFG 2, BFG 3, BFG 4, BFG 5, BFG 6, BFG 7, BFG 8, BFG 9 and BFG 10 and BFG 11. Data saturation was reached at participant BFG 11.

4.3. Summative analysis of participants

The participants in the study have a diverse range of years of experience, and the majority (60%) have a substantial tenure of six to eight years, indicating a solid foundation of knowledge and skills acquired over the years. Moreover, 20% of the participants have experience in their roles falling within the three- to five-year range. The other 20% are among the most experienced, with an impressive nine to ten years of experience in their domain. Overall, the group is heavily skewed towards those with considerable experience, ensuring rich knowledge and practical understanding among the participants (see Figure 4-1). As shown in Figure 4-1, the highest qualification is a PhD (40%), followed by MEng (60%), which qualifies the participants based on the inclusion criteria stipulated in Chapter 3. Moreover, the distribution of qualifications indicates that the research centre is multidisciplinary. The disciplines include physics (10%), chemistry (30%), chemical engineering (20%), electrical engineering (10%) and mechanical engineering (30%). Figure 4-1 shows the years of experience and highest qualification of the participants.



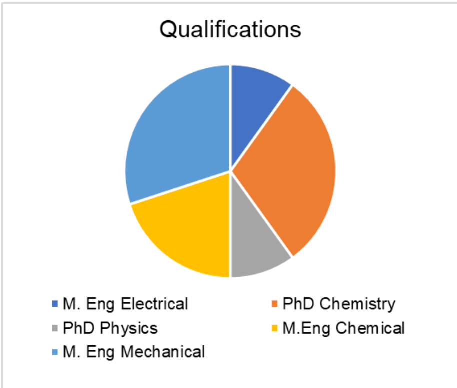


Figure 4-1: Years of experience and highest qualification of the participants employed by the research centre

4.4. Thematic analysis process

The thematic analysis for systematic identification and analysis of patterns or themes was conducted as described in Chapter 3. After data familiarisation, open coding was used to explore the data to code text segments systematically and to generate themes. These themes were reviewed and defined accordingly. To delve into theme relationships, the network diagram feature is invaluable, visualising connections and revealing data intricacies (see Figure 4-2 and Appendices A1-A3). The word cloud generated by ATLAS.ti provided a visual summary of frequently occurring words or concepts (see Appendix A4). Table 4-1 shows a summary of codes, themes and quotations.

Table 4-1: Summary of codes, themes and quotations

Codes	Themes/subthemes	Sample quotations
Prototype; potential investors outsourcing; development of whitepapers; early stages of R&D; no detailed market strategy; no commercialisation plan; market research	Commercialisation and launching potential	"We try to make the prototype of the ideas" "So some projects may require publication of a paper, or developing a white paper" "We are in the early stages of R&D, so in terms of market research honestly, the market research that we have done, we have been outsourcing"
Adaptable; align with commercialisation	Method flexibility	"...all the steps are relevant because we have teamed up with a project-based company that would make use of my product commercially"
Resource availability; communication; project scoping, strong team; management support; marketing; right skills	Key drivers	"Human Resources to me is very important. You need to invest in them, you need to train them, and everyone must have project management skills"
Determine time frames; deliver on time; very effective	Effectiveness	"When it comes to timing and budget, we always deliver on time so far. "
No structured method; Waterfall; no specific method	Existing PM method	"So we use a type of Waterfall type of Project Management." "We don't really have procedures"
Brainstorming; testing and validation; literature review; project scoping; technical feasibility	R&D processes	"There is a lot of testing and validation to make sure that you are on track"
Miscommunication; skills challenge; underbudgeting; limited resources; scope creep, behind schedule; procurement delays	Operational management	"There is just miscommunication regardless of what the topic is or during which phase the project is in" "The procurement stage is also sometimes very challenging because it cannot be controlled" "Procurement stage is also sometimes very challenging because it cannot be controlled"
Risk mitigation strategies; risk officer; economic analysis	Risk management	"There is the economic analysis which is in the business plan" "We have a research officer inhouse who does risk assessment"
Expert decision making; client feedback; high-impact factor journals	Quality management	"..the form of paper publication, which can go to the higher impact factor" "but I also feel like if the decision makers could be experts, people who really know what is happening on the ground"

Source: Researcher's own data

4.5. Discussion of findings and interpretation

The research mind map shown in Figure 4-2 elaborates on the human experiences and insights drawn from the raw data collected. At the core of this mind map, there are themes, which are broad patterns that have emerged from the participants' narratives. These themes cover the essential meaning of a large volume of data. At the periphery of these themes are subthemes, which are more specific insights related to a broader theme. Subthemes are more detailed and help to illuminate the nuances of each overarching theme. Moreover, the themes shown below are interconnected, revealing relationships between different aspects of the research topic. The interconnected themes relate to the commercialisation and launching potential, which are key to the overall aim of this study. This interrelationship between themes showcases the complexity and richness of the human experience under study, emphasising the holistic and interconnected nature of qualitative insights. Figure 4-2 shows a mind map illustrating the relationship between themes and subthemes derived from the participants' narratives.

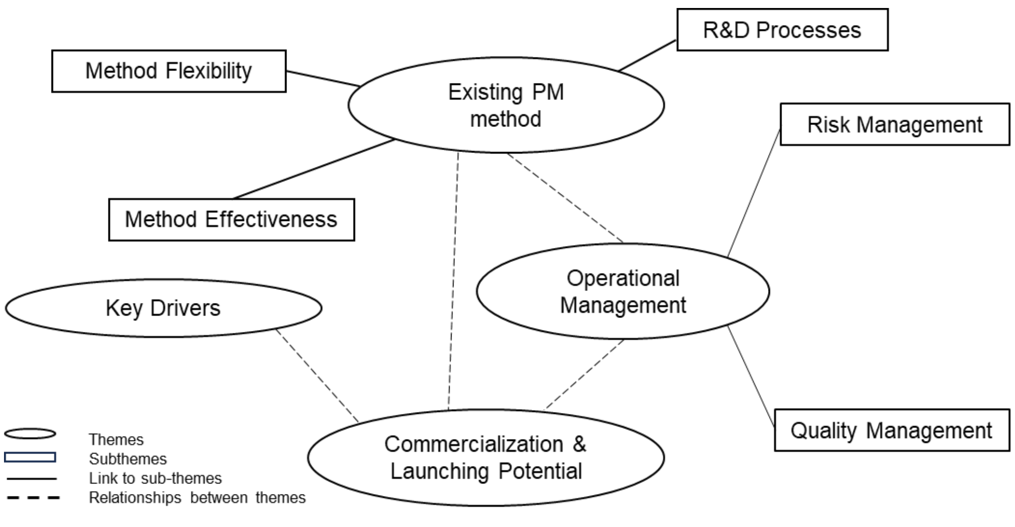


Figure 4-2: Thematic map showing the relationship between themes and subthemes derived from the interview transcripts

4.5.1. Existing project management method

Project management (PM) is the process of leading the work of a team to achieve all project goals within the given time and budget constraints. Therefore, the researcher intends to comprehend the current PM method used to manage R&D projects at the research centre. Only one participant mentioned Waterfall and most participants interviewed in this study indicated that the research centre does not follow a specific method of managing R&D projects. Therefore, other participants did not mention any of the well-known methods, including lean startup (Bortolini *et al*., 2021:1765), design thinking (Dell'Era *et al.,* 2020:324-327), waterfall (Thesing *et al*., 2021:747), agile development (Silva *et al*., 2020:595-598), and customer development (York & Danes, 2014:21-27). The interview outcomes align with Powers and Kerr (2009:2-5), who acknowledged that academic research institutions rarely follow a structured PM approach in managing research projects. Instead of leveraging the abovementioned structured industrial frameworks that are widely recognised, the indications are that the research centre relies on a more *ad-hoc* or informal approach.

Participant BFG 1: "*We don't have a specific procedure that we follow, the projects that we get… they vary*"

Participant BFG 2: *The current project management method currently being used, I wouldn't know what it is but I do know that we are involved in some of the stages*

Participant BFG 11: *We don't have a specific name for the method, but we follow in general the following steps: we start with the identification of some problems, especially from literature survey. We also brainstorm about hypotheses and ideas to tackle those problems, then we come up with a set of objectives which are limited to the specific problems we will have identified, and the solution we want to achieve*"

Participant BFG 6: *"I don't know whether we are following a method or what, because normally we just run the project as they are, so the 1st thing that we do, we just brain storm, then we do literature review, after which we select our method that we want to follow, maybe if there is such a method. Then from there, we do preliminary study maybe in the lab to check whether those methods work or not; if they work, we carry on, if not, we go back and revise the literature to see what is going on or what went wrong, or what can be improved from those methods"*

Participant BFG 8: *"With our projects that we work on, and the current state of our management, there is a level of project management style which is not consistent"*

The abovementioned approach to R&D projects might bring advantages such as flexibility, but it may also pose challenges. With the lack of formal structure to run projects, there may be issues such as inconsistent timelines for deliverables, communication bottlenecks, or the risk of overlooking the project's critical parts, leading to catastrophic project failure (Fernandes *et al.,* 2015:1066,1067). Based on the researcher's own experience, if the project fails, funders may decide to keep the remaining portion of funds until they are satisfied with the measures put in place to correct the failure. In this case, the participants suggested evaluating the current practices and adopting a more structured method of managing R&D projects. This may improve efficiency, consistency and the success rates of the projects.

4.5.2. R&D processes currently followed

The participants indicated that the actions that are normally taken within the R&D projects include brainstorming, identifying gaps throughout the literature studies, and conducting laboratory experiments. The laboratory experiments mentioned refer to proof of concept or preliminary experiments used to determine the technical feasibility of the project as well as testing and validation. The participants also mentioned that they perform scoping before any project may commence. Project scoping involves defining and documenting the project's objectives, goals, deliverables, tasks, timelines, and all resources needed (Edgett, 2015:4). It provides a concise and clear outline of the project's scope: what it entails, its intended achievements, and what will be excluded from the deliverables.

Participant BGF 6: *"So the first thing that we do, we just brainstorm, then we do literature review, after which we select our method that we want to follow, maybe if there is such a method. Then from there, we do a preliminary study maybe in the lab to check whether those methods work or not; if they work, we carry on, if not, we go back and revise the literature to see what is going on or what went wrong, or what can be improved from those methods"*

Participant BFG 2: *"I think it does. Like I mentioned earlier, we take an idea, say from a research output, usually a theoretical aspect of the project, and the people do a lot of research and come up with an output, which is just intellectual property, and then we see if we can build a prototype from that research, and then, if we can build a prototype from it, and see whether this prototype can meet some specific market or demand, and if it is competing well"*

Participant BFG 4: "*Some projects require a bit of more detail, other projects do not really require detail. I'd say at the initiation of the projects, I'd do a proper planning, I'd* *set the stage scope, then you look at how you're going to execute all of these steps that we talked about, the planning, how you're going to do it. Then obviously, you have the project monitoring and controlling steps, where you look at the projects, you monitor, you control, and you make sure that your schedule is on budget"*

It is important to perform proper scoping in order to keep the project on track and within the stipulated budget and timeline while meeting its intended objectives. Communication and regular meetings play a vital role in keeping the team aligned and progressing towards the project objectives. The participants emphasised that the availability of resources (funding, human capital, equipment) is important when running an R&D project. Despite the fact that the centre operates without a specific method, there are systematic steps for running projects. Meanwhile, a systematic approach ensures that important steps are not missed, whereas the absence of a rigid structure can also offer freedom of flexibility. Flexibility can be valuable in R&D projects where unpredictability is prevailing. According to Ismail and Mansor (2018:5216-5218), non-flexible methods do not provide opportunities for iterations and are operated on fixed budgets and timeframes resulting in delivering a product to the client or nothing due to failure. However, there is a fine balance. Too much flexibility without a proper guiding structure can lead to chaos, inefficiencies, and a lack of clear direction. The end results may put the entire organisation at risk of losing clients, investment opportunities and skilled workforce.

It is clear from the interviews that the participants are not involved in the same projects, and therefore do not follow similar steps for all projects. For example, the relevant steps in engineering projects are conception, scoping, design and manufacturing, testing and validation or commissioning, while scientific project steps may include ideation, literature review, proof-of-concept, experiments, up-scaling, testing and validation. Some of these steps overlap in both scientific and engineering projects and have some elements of the Stage-Gate method. Therefore, taking advantage of this alignment, projects at the centre can be customised based on the three-step Stage-Gate or five-step Stage-Gate method, depending on the complexity of the project (Cooper, 2008:223).

4.5.2.1. Flexibility in implementing the Stage-Gate

Participants indicated that the Stage-Gate method is a formal structure and interesting and believe it can be applied to their own projects. They believe that all stages are relevant but should not be applied blanketly to R&D projects. This means that the Stage-Gate method must be customised to be relevant for a particular project. The Stage-Gate method is flexible and can be tailored based on the nature of the risks of different types of projects (Kotter, 2007:60-67). The adaptableness of the Stage-Gate method has been proven by different types of industries, including automotive, energy, IT, petrochemicals, and chemicals (Stage-Gate International, 2023). Participants mentioned that the centre does not use Stage-Gate, but suggested that it could be beneficial to raise public awareness to encourage its adoption. They further elaborated that, in their opinion, the implementation of the Stage-Gate method could be easier in small projects where there are fewer factors to consider. It seems the participants are unaware of the Stage-Gate method that is designed for low-risk or small projects (three-step method) and complex projects (five-step method). Some elements of Stage-Gate are found in the current method used by the centre to run R&D projects. Although it is not a structured method, participants mentioned steps such as brainstorming, literature review, method selection, testing and validation, and creating a business plan, which align with the Stage-Gate method. The importance of market studies and feasibility assessments for the commercialisation of products is noted. Participants also discussed the importance of communication within their team and further acknowledged that implementing Stage-Gate can be challenging in a dynamic R&D environment.

Participant BFG 1 *"...in my case, it applies to the first 3 or 4 gates, the others, we don't really apply it much"*

Participant BFG 11: *"Stage Gate is an approach that speaks to all disciplines, including the one that we are working on. So, in our case, since I know now about the Stage gate approach, it will be important to specify the roles at each step of the development* of the project, so we have ideation, it has its role, investigation, it has its role".

4.5.2.2. Effectiveness of the current PM method

Some of the participants indicated the manner in which projects are managed is reasonably effective but there is room for improvement. Indications are that projects are somewhat consistently delivered on time and within the specified budget. The importance of financial planning and budgeting is emphasised as this ensures that projects are allocated funds sufficiently. Therefore, the participants mentioned that they consider operational costs when determining project scope and team size. It is indicated that resource allocation is relatively easy for small projects, and they make sure to allocate funds for potential emergencies or changes in prices. Therefore, the current unstructured method is moderately effective, with an emphasis on planning, budgeting, and considering various costs.

Participant BFG 2: "*From what I have observed, especially from a technical perspective is that the entity ideally should be result oriented. So, if the anticipated results are commercialization, then everyone works hard to make sure that we get to the goal, and then stakeholders will not have to continue"*

Participant BFG 3: *"I think its reasonably effective if it is applied consistently. But I think it can be a little bit better. It is good, but it can be better*"

Participant BFG 9: *"Its effective, because we do not disappoint our stakeholders or funders, so we set a realistic expectation, and this is based on, if you are developing a product, there has to be many tests that are done to see how long it will take"*

Participant BFG 10: *"Not so effective, as far as I'm concerned, it's not. There is a lot of unforeseen obstacles...."*

4.5.3. Operational management challenges

Research and development projects, whether large or small, are often confronted by setbacks and delays that come from unforeseen challenges. Here, the researcher aims to explore the type of operational challenges experienced at the centre and whether these issues are related to the unstructured PM method. The participants indicated that procurement delays can be a major stumbling block. It is well known that factors such as geopolitical conflicts, transportation challenges, or even vendor-specific problems can lead to major disruptions to the supply chain (Passarelli *et al.*, 2023:1305). Even with the best planning in place, a piece of specialised machinery or equipment can be out-of-stock or broken, causing significant delays, especially if replacement or repairs are time-consuming. Projects may end when budgets do not match reality, due to underestimation of costs, and unexpected inflation. According to the experience of participants, finding employees or contractors with the specific skills and knowledge needed can be a daunting task, with each job's specific requirements. This challenge can be compounded if time constraints are limited or the skills required are scarce. Furthermore, projects can suffer from miscommunication between team members or stakeholders. The slightest misunderstanding can lead to a significant departure from the project goals.

Participant BFG 5: *Sometimes its human resource, financial resource or even resource in terms of equipment. If you talk about human resources, these are usually very key in terms of running a project. So we need to identify a proper team with an adequate set of skills to execute the project.*

Another challenge indicated by the participants is the lack of project documentation, which can mean that important information is lost, not shared, or misunderstood. Documentation, within this context, refers to operating manuals, safety documents and design specifications. Therefore, projects without a proper paper trail will lead to errors, damage to equipment, and safety issues, especially if there are new employees involved. The abovementioned issues can be mitigated by planning ahead, anticipating potential challenges and preparing for contingencies.

4.5.3.1. Risk management

According to the occupational health and safety policy of the institution, before starting any project, a risk assessment must be conducted for the purpose of ethical clearance and to identify any potential risks related to experiments and any other tests. Therefore, participants highlighted that a risk officer evaluates the risks associated with all of the projects and develops a mitigation plan. The research centre is aware of project risks, and consequently the participants indicated that the project planning phase includes determining the timeframe and budget, as well as involving the necessary personnel. Feedback from external parties (stakeholders and clients) is sought to identify potential issues related to the project. Participants highlighted that the literature review helps determine the project's needs and potential improvements, which also helps identify potential issues relating to resource availability. After conducting a risk assessment, the mitigating plan is implemented to minimise risks. Failure points are considered, and projects may be abandoned or put on hold if risks are deemed too high. Project prioritisation can be influenced by external pressure such as industry partners or government as funders. Regular monitoring and communication are essential to ensure progress and to address any underlying issues that may occur. As recommended by participants, proper documentation, economic analysis, make or buy decisions, and sensitivity analysis are also important factors to consider.

Participant BFG 2: "*One of the biggest challenges faced so far is communication. Poor clarity of goals, and sometimes, maybe in the SA context, things like knowledge sharing as well*

Participant BFG 3: "*Problems arise because of miscommunication and individuals are not being transparent or clear about important matters that need to be addressed*……… *Not having the right documentation structure in place"*

The challenges experienced by the participants are widely known as being associated with the absence of a structured project management approach. This is described in the literature and it was pointed out that the lack of a structured approach can result in exceeding the project's budget due to inflexibility, late identification of technical problems, lack of accountability, poor communication, and chaotic management (Kassa, 2020:102; Kasauli *et al*., 2020:31; Walker, 2017:180-185).

Participant BFG 7*: The biggest challenge I would say would be to manage the project timelines within our environments. The other challenge would be the scope creep... That's another challenge-adapting to scope and correctly adapting to scope change..."*

Participant BFG 8*: "The other challenge is flexibility. This can involve budget constraints"*

Participant BFG 5*: "Procurement processes and supply; people management-these are some of the challenges we meet in the kind of project we do*"

Participants highlighted that to keep the project within the stipulated budget and allocated timeframe, careful planning is needed during the initial stages to establish clear timelines and budget boundaries. According to the participants, the size of the project usually dictates its duration, and once a budget is determined, it is important to stick to it because changes can be challenging. Furthermore, participants also indicated that timelines are sometimes established based on reviewing data from similar projects that are completed. It is important to keep continuous communication and updates on the progress to ensure that everyone remains aligned and on track.

Participants also raised an issue of *scope creep* – when unexpected tasks arise there is a potential risk of elongating the project or increasing costs. Here, the project manager plays a pivotal role, consistently monitoring the progress and ensuring that everyone is included in critical decision-making. The goal is to maintain an environment where everyone is aligned, informed, and engaged, which, in turn, ensures the successful and timely completion of projects. According to Cervone (2010:18), R&D projects are more likely to exceed the stipulated budget and time due to a lack of structured approach in the process of development.

Participant BFG 8: *“...most of the time the projects are the same, so they repeat. Even if you’re dealing with 3 projects, there is always 70% similarity between the projects. You already know that if we are working on this project, there is this particular system that we need, this particular component that we need. So in that sense, we always plan ahead, that ok, we’re going to work on...”*

Breaking down the risks:

a. Procurement delays: A structured project management method must include risk management strategies, which anticipate any potential challenges such as procurement issues and supply chain disruptions and provide mitigation plans and guidelines in advance.

b. Cost overruns: A proper project management method entails rigorous budgeting, financial forecasting, and continuous monitoring of expenses against the allocated budgets.

c. Talent acquisition: Proper planning includes talent management where resources with the required skills are identified early and engaged for the duration of the project.

d. Miscommunication: A structured approach emphasises regular communication and has tools and processes in place to ensure that all stakeholders are aligned and understand their roles, tasks, and responsibilities.

e. Lack of documentation: This is a fundamental component of structured project management. Proper documentation ensures that every process, decision, and communication is recorded and can be traced back if required.

f. Risk management: As mentioned above, while the centre does conduct risk assessments, it is an integral part of the structured project management method to not just identify risks, but also to continuously monitor and update these risks as the project progresses.
g. Feedback mechanism: Engaging stakeholders and clients for feedback and integrating that feedback is an essential part of a structured approach.

Indeed, the method followed by the research centre can be associated with Waterfall based on the following issues derived:

a. The are no decision points or quality controls during the project lifecycle.
b. Indications are that, if one stage gets delayed, all subsequent stages are delayed.
c. There is no process overlap, and therefore the efficiency is reduced.
d. A specific deliverable will be available only in the final stage of the project.

4.5.3.2. Quality management

In terms of quality, participants indicated that they rely on client feedback to measure the quality of the output and furthermore publish work in high-impact factor journals. The latter suggests that if the manuscript is accepted for publication in a high-impact factor journal, then the method currently used has a significant impact on the quality of the outputs. For this R&D centre, outputs are publications, patents, postgraduate students, as well as demonstrations and pilot plants. Participants indicated that decision-makers should be subject matter experts who consult with individuals on the ground, as this may have an impact on the quality of the outputs. Based on this information, it is clear that there is a lack of quality control protocols within the research centre. The Stage-Gate method allows gatekeepers to make the decision whether to continue or stop the project based on the criteria that were put on the table (Cooper & Edgett, 2012:5). Therefore, the participant mentioned the value that the Stage-Gate reviews will add and the risk of setbacks that might occur in the process. In this case, Stage-Gate may set high-quality standards depending on the criteria set at each gate. According to Cooper (1990:46), each gate serves as a quality checkpoint. Participants also indicated that having distinct milestones boosts morale and that the Stage-Gate draws attention to paused or ongoing work.

The Stage-Gate process, if implemented correctly, is likely to produce enhanced quality, discipline, and overall performance compared to informal development processes (Sommer *et al*., 2015:41). A participant warned that Stage-Gate will require greater reporting and micromanagement. Furthermore, they claimed that while Stage-Gate may not be optimal in a scientific R&D setting, it may help with people's desire to follow instructions. However, Cooper (2008:215-218) argued that the Stage-Gate process is not a rigid, bureaucratic, data entry system, a lock-step procedure, or an outdated and stagnant system. According to Cooper (2008:215-218), Stage-Gate is a flexible and adaptable method that can be customised to the specific needs of each project or organisation.

Participant BFG 1: "*I also feel like if the decision makers could be experts, people who really know what is happening on the ground, or if they could take the time to consult*"

Participant BFG 5*: "In the quality of our outputs, these can be in the form of paper publication, which can go to the higher impact factor. I wouldn't want to say it'd improve, but maybe it involves a lot more reporting, a lot more micromanaging, so it might affect the proper workflow because you're incapacitated*"

4.5.4. Key success factors

Key success factors within the context of this study refer to the fundamental elements that contribute to the successful implementation of the Stage-Gate method. The participant mentioned that the Stage-Gate method should be more agile in R&D projects. Indeed, R&D projects are unpredictable, and flexibility is needed to be able to adapt to any changes that may occur. Participants also emphasised the importance of communication, proper team composition, and investing in human resources forming an integral part of the Stage-Gate. This is in agreement with Edgett (2015:2) and Florén *et al.* (2018:417-418), who also argue that resources extend beyond just financial backing, but also encompass human resources, physical resources, technological resources, and time. Participants also believe that decision-makers should have technical knowledge and be involved in decision-making processes. This is an indication that support from management is needed to implement Stage-Gate successfully. For example, management with technical knowledge can be gatekeepers and will be able to make decisions during Gate review meetings (Edgett, 2015:1-2).

The participants suggested implementing these changes from the top management level and ensuring that stakeholders are informed and involved in project reporting. This is a pivotal factor as senior management with a technical background will be able to drive the cohesiveness and collaborative effectiveness of cross-functional teams towards a common goal (Bhuyain, 2011:750). The involvement of stakeholders in the process is important for keeping good relationships with people who have the most impact on the successful delivery of the project. Overall, participants suggested that for the Stage-Gate to be successful and effective, there must be a clear definition of scope, relevant skills, team collaboration, proper resource allocation, thorough preliminary investigation, product development, testing and validation, and an effective product launching plan.

Participant BFG 1: *"that I feel like management or decision makers should also be…. I can't really say technical. But we should also be allowed to be involved in decision making"*

Participant BFG 2*: "I think from the bottom, I think there is a strong team that can work towards achieving this goal. I'd suggest maybe a restructuring or a way from the top management ….if we could have a way of implementing it from the top. From the bottom I think the personnel is there, the resources are there; I think it'd just take …I wouldn't call it a restructuring as such, but a more managerial approach"*

Participant BFG 4: *I think you must have a structure that you can apply, it's a newer type of look out in various project managements, and what I like about it is that there is a lot of emphasis on scoping, and then depending on your outcomes, especially when coming to the commercialization phase, where you have your business case and your project plan working together*.

Participant BFG 7: *That would be support from senior management; they need to buy into the change of the whole approach with regard to the project, so the director needs to buy in, and allow the implementation of it, and then education of the project managers. That'd be the 2 things that need to be implemented, for that to be rolled out in an R&D facility*.

Participant BFG 8: *"That would be support from senior management; they need to buy into the change of the whole approach with regard to the project, so the director needs to buy in, and allow the implementation of it, and then education of the project* *managers. That'd be the 2 things that need to be implemented, for that to be rolled out in an R&D facility"*

Participant BFG 5: "*in terms of research, a more agile method is needed because in R&D a much smarter approach is needed, where agility is actually key, rather than a rigid framework for R&D"*

4.5.5. Commercialisation and launching potential

In this section, the researcher aims to explore the resources and guidelines in place to build a business case with the end goal of commercialisation and product launching. The information collected from the participants revealed that the research centre is focused more on R&D projects and not the entire value chain. This is an indication that there is no product that is already on the market, but prototypes are available. The research centre has been outsourcing market research on specific projects and at the moment there is a detailed plan for commercialisation, but which has not been implemented. Collaboration with stakeholders and potential investors is a potential area of benefit for the research centre. They are currently at the stage of developing prototypes and demonstrators. While the research centre is in the early stages of R&D and there is no product already on the market, other points suggest a clear trajectory towards the goal of product commercialisation in the future. It must be noted that the research centre has multiple projects and not all of them will be planned for commercialisation. Therefore, other participants indicated that they are focused mainly on R&D and not on commercialisation. Therefore, this is not a contradiction, but the views of participants working on different projects.

Participant BFG 1: "*We are in the early stages of R&D, so in terms of market research honestly, the market research that we have done, we have been outsourcing"*

Participant BFG 2: *"For some of the projects that we have been working on, I've seen detailed plans and a lot of market research being done. In fact, the market research is actually the backbone for most of the arguments that we present when we are trying to get funding*"

Participant BFG 4: "*One must be careful when you let your academics and your engineers to the market area. That's more of a business case. To be honest, I don't think we go into market research, those are normally done by the university business case people*"

Participant BFG 8: *“And based on my own observation, when it comes to the way we approach projects, to me it does not seem like there is that detailed plan such as market research. I do not see projects that are taken with the intention to develop and commercialize projects. I think its linked to what I mentioned earlier that there is a disconnect in terms of the structure of the organization”*

The scalability of R&D products is important to meet future industry demands and for commercialisation. Therefore, a participant elaborated on evolving changes to align with the commercialisation strategy. In this case, the participant is involved in catalyst development, and she indicated that they started using small batch reactors and then scaled up to bigger reactors to validate the scalability. According to the participants, there are a few changes organisation-wide and they have not used Stage-Gate in their research yet. Furthermore, the participants indicated that they have a work plan that outlines the tasks, goals, and timelines for completing a project or achieving specific objectives. This serves as a roadmap for organising and managing work activities. Setting clearly defined and achievable project goals is important for the project’s success and reduces ambiguity where team members have no clue regarding the project direction (Edgett, 2015:1-2).

Participant BFG 6: *“We have worked from a small scale, so we just went to bigger reactors twice......we increased the production.”*

Participant BFG 7: “*Yes, we tried to move towards a point where we actually finalize the design, or first finalize the scope in the user requirement specification, then there is the design. So we are moving towards the point where we actually have documentation which is finalized and completed, and basically get into a final stage before moving onto the next stage”*

Participant BFG 8: “In my own capacity, I only implement a workflow that works for me to be able to deliver my roles and responsibilities in each project for me to be able to do it within a specified time. So, across the spectrum of the organization, no”.

4.6. Key findings

The key findings below are discussed based on the objectives outlined in Chapter 1 of this research study with the aim of exploring the application of Stage-Gate to manage R&D projects in an academic research centre.

4.6.1. The current project management approach used at the research and development centre

It was found that the research centre does not use any of the well-known industrial project management methods to manage its R&D projects. A sequence of steps such as brainstorming, literature reviews, experimental evaluations, scoping, testing and validation are taken to conduct research activities. However, this is a comprehensive approach to research problem-solving and lacks the fundamental aspects of the PM method. To mention a few, the fundamental aspects of PM include managing resources, risk, people, and project scope. Even though the currently used method by the research centre under investigation follows a sequence of steps, when evaluated within the broader context of project management, the method may be described as unstructured.

There is a correlation between the described method and the Waterfall method in terms of linear progression and validation steps. This is in agreement with Yaw Koi-Akrofi et *al.* (2019:38-39), who reported that R&D centres have mostly used methods that are aligned with the traditional Waterfall approach to manage projects. Furthermore, Powers and Kerr (2009:2-5) assert that research institutions, especially those in the academic environment, do not follow a structured approach to managing research projects. This study was conducted in one research centre, and this is not enough to provide a general conclusion that all research centres in academia do not follow PM methods.

4.6.2. The management challenges with the ongoing projects caused by the current management approach

The challenges experienced by the participants with the current method in place include poor communication, scope creep, procurement delays, cost overruns, lack of documentation, and lack of feedback mechanisms and quality controls. These challenges are common in projects and are also reported in the literature by some of the authors (Kasauli *et al*., 2020:31; Walker, 2017:180-185). As explained in 4.5.2, the currently used approach does not take into account the fundamental PM aspects that are meant to mitigate the very basic challenges experienced. The consequences of these challenges include decreased likelihood of the projects being completed on time, within budget, and to the desired quality standards. This reputational damage will negatively affect future investments and will put a strain on all stakeholders involved.

4.6.3. Enablers for a successful implementation of a Stage-Gate method as an alternative management tool in the centre

The enabling ecosystem within the R&D centre that will lead to the successful implementation of Stage-Gate includes the availability of a well-experienced team with a variety of skills. This is justified by the multidisciplinary nature and the level of qualifications of the team, as presented under demographics. Despite the challenges, the research centre has set clear goals for the commercialisation of R&D products. This vision alone unlocks the need for the research centre to seek the proper PM method to reach the desired goals. Indications are that the Stage-Gate method will be easily integrated, simply because the unstructured method currently followed partially overlaps with some of the Stage-Gate steps.

4.6.4. The critical success factors of the Stage-Gate method in a research and development centre

The critical success factors established in this study include a clear definition of scope, recruiting relevant skills, encouraging team collaboration, good communication, proper resource allocation, thorough preliminary studies, a product development plan, and an effective product launching plan. The involvement of management and project leaders will perform quality control checks through gatekeeping of Stage-Gate. These critical success factors are in line with those reported by Edgett (2015:2) and Florén *et al.* (2018:417-418), who also explained that resources are not only financial, but also include other important components such as human capital, equipment, and time.

4.6.5. Customising the Stage-Gate method to align with the objectives of the research and development centre

It was found that the research centre has projects in the field of engineering, which includes disciplines such as electrical, mechanical and chemical. Scientific projects are in the fields of chemistry and physics. In the case of the research centre, the engineering projects are generally complex and incur high costs as they involve manufacturing and assembling of large systems and demonstration plants. In general, risk refers to the significance of various types of threats posed to the project team's ability to deliver. Scientific projects can be ranked from low to medium risk as they usually include fundamental computational research and laboratory-scale operations. Therefore, a five-step Stage-Gate method can be customised for engineering projects and a three-step method for scientific projects. Using this approach, the less risky projects will reach the commercialisation and launching phases faster.

4.6.6. The strategic guideline to assist in building a business case for products developed within the research centre

A budget must be allocated to conduct extensive market research for selected projects. This will be beneficial in building a business case and developing the marketing strategy for potential products. Building a cross-functional team comprising representatives from R&D, commercial law, marketing, finance, and other strategic and policy divisions can foster diverse perspectives and collaborative problem-solving for the successful implementation of Stage-Gate. Delegating different roles to this team in various parts of the Stage-Gate method will expedite the transition from R&D to product launch.

4.7. Management implication and contribution

The insights obtained from the Stage-Gate method can help an organisation improve its strategic planning, policy development, operational efficiency, and, ultimately, its ability to achieve long-term success. Below are some of the key aspects involved:

a. Aligning with funding agencies

An organised approach to project management and reporting is commonly required by various funding agencies. The Stage-Gate method can assist in aligning with such requirements, making securing and maintaining funding easier.

b. Academia-industry partnerships

The Stage-Gate method can also assist in aligning academic research with industry and market demands, increasing the relevance and impact of the R&D conducted by the research centre.

c. Continuous improvement

The Stage-Gate method's structured feedback and review process fosters a culture of continuous development and learning, which may be extremely beneficial in advancing the research centre's project management maturity over time.

d. Risk management

The gates serve as quality control points, ensuring that the research results match set criteria and standards. Additionally, risks can be identified and mitigated in a timely manner at each stage, promoting a culture of quality assurance and risk management.

e. Resource allocation

This method aids in optimising the allocation of resources by allowing managers to assess the viability and progress of projects at each gate, thereby ensuring that resources are channelled toward projects with the most potential.

f. Commercialisation and revenue creation

Since the research centre is aiming at commercialisation, the Stage-Gate method can expedite the transition from R&D to market launch by systematically addressing the requisites for commercialisation at each stage. This could influence policies related to intellectual property, revenue-sharing, and market engagement.

g. Contribution to literature

To the best of the authors' knowledge, there is no previously published report that has investigated the application of Stage-Gate method in managing R&D projects at an academic institution. This study contributes to the academic community by providing knowledge on customizing Stage-Gate method based on the risk profile of the projects. Moreover, the study acts as a stepping stone for students and new researchers, whereby the Stage-Gate method can serve as an educational tool for decision-making, and strategic planning in a research context. The study also provides in-depth exploration of the challenges associated with informal PM methods, such as miscommunications, scope creep, and lack of documentation. Remarkably, the study provided insights on the enabling ecosystem and critical success factors linked to the successful implementation of Stage gate.

4.8. Chapter summary

The chapter explored the interconnection between the applied method of managing R&D projects, key success factors, commercialisation, and launching potential, identified as building blocks (themes) enabling the implementation of the Stage-Gate method within the academic research environment. Through in-depth interviews, it was revealed that the research centre randomly follows an unstructured method that encompasses brainstorming, literature review, scoping, and laboratory experiments. According to the participants, the key success factors for effective Stage-Gate implementation include agility, proper resource allocation, technical knowledge among decision-makers, and effective communication. The difference in project approach as alluded to by participants in both engineering and science projects suggests customising the Stage-Gate process per project requirements. Moreover, the unstructured PM method led to several challenges such as budget overruns and prolonged timeframes, which can be resolved by the structured Stage-Gate method. The R&D value chain is limited because at the moment there is no evidence of products that are already on the market. In terms of commercialisation activities, although not exhaustive, the market research is outsourced and some of the R&D work has reached the prototyping phase.

CHAPTER 5

CONCLUSIONS, RECOMMENDATIONS AND FUTURE RESEARCH

5.1. Introduction

The previous chapter delved into presenting and discussing the findings derived from the data collected during the qualitative research process. This chapter reflects on the conclusions pertaining to this study as well as the recommendations to guide the implementation of Stage-Gate in an academic research centre. Moreover, this chapter also presents the limitations encountered in this study, managerial implications, and future research.

5.2. Conclusions

In this qualitative study, the research methodology is underpinned by the interpretivist research paradigm and inductive approach using open coding. This is to explore the implementation of the Stage-Gate method within the academic research centre based on the experiences of its employees (participants). Data was successfully gathered using a method of convenience sampling and semi-structured interviews. There is no doubt that the high level of qualifications (MEng and PhD) and years of experience of participants in the R&D field have contributed to the richness of the data.

This study revealed that the informal or *ad-hoc* PM method followed at the R&D centre is the course of the operational challenges being faced. It was found that the steps followed in this informal method echo some of the structured stages of the Stage-Gate method and make it easier to implement. The key challenges experienced by employees of the centre include inconsistent project timelines, miscommunication, lack of risk management and quality control, procurement delays, limited resources, poor documentation, scope creep, and budget overruns.

Therefore, introducing a more structured and disciplined approach such as the Stage-Gate method will mitigate the challenges mentioned. Furthermore, addressing these challenges will make the processes of commercialisation and launching of products much easier. It was revealed that the availability of management support, technical skills, proper resource allocation, and strong cross-functional teams and stakeholder engagement can improve the commercialisation readiness and success rate of projects. The approaches to different projects, as noted by different participants, also highlight the importance of customising the Stage-Gate and commercialisation strategies based on the unique objectives and contexts of each project.

Table 5-1: Summary of answers to the research questions of this study

Research question	Findings
What is the current project management approach used at the research and development centre to manage its projects?	Informal and unstructured PM method that involves steps such as, brainstorming, scoping, laboratory experiments, testing and validation.
What are the existing project management challenges about ongoing projects caused by the management approach in place?	The challenges include miscommunications, scope creep, procurement issues, cost overruns, lack of documentation, and lack of feedback mechanism and quality controls.
What are the enablers for a successful implementation of a Stage-Gate method as an alternative management tool in the centre?	Availability of a well-experienced R&D team and support of top management. Clear organisational objectives regarding commercialisation. Smooth Stage-Gate integration: The informal method partially overlaps with Stage-Gate.
How does the critical success factors of the Stage-Gate method in a research and development centre minimise the existing management challenges?	Clear definition of scope, relevant skills, team collaboration, proper resource allocation, thorough preliminary investigation, product development plan, and an effective product launching plan. The involvement of management will assist in gatekeeping for quality control. Communication will be improved through gate review meetings.
How is the Stage-Gate method customised to align with the objectives of the research and development centre?	Engineering projects: High risk and complex (five-step method). Scientific projects: Low to medium risk (three-step method).
How would a proposed strategic guideline for the implementation of the Stage-Gate method assist in building a business case for products developed in the research centre?	Market research will provide data for the business case. Stage-Gate will help in the expedition of the transition from R&D to market launch, promote academia-industry partnerships, align with funding agencies, and improve quality control and risk assessment.

5.3. Recommendations

The recommendations provided here serve as guidelines for the successful implementation of the Stage-Gate method within the research centre in question. It is important to first educate and get support from all stakeholders involved in projects including the senior management and the research team as a whole. The research group leader of each team, including both middle and senior management, should assume the role of gatekeeping and must be involved in crafting the criteria of each gate based on the objectives of each project and the organisation. At the heart of the organisation, a cross-functional team comprising representatives from R&D, marketing, finance, and other pertinent departments, can foster diverse perspectives and collaborative problem-solving for the successful implementation of Stage-Gate. By doing so, the Stage-Gate model will be customised to align with the goals of the organisation. In terms of the fit-for-purpose Stage-Gate method, further assistance can be obtained from Stage-Gate® International, which provides services for various industries.

After all information has been gathered, management can execute a pilot programme that will help in adjusting and/or customising the process according to the practical insights and experiences of each project. At this point, the team is aware of the level of risk of each project and will customise Stage-Gate accordingly. For example, low-risk projects will use a two- or three-step Stage-Gate and high-risk projects will use a customised five-step Stage-Gate method. It will be beneficial to establish regular Gate review processes, employ project management software, and encourage a culture of open communication. It is crucial that the decision-makers or gatekeepers are well informed about the *go* or *no go* decision. Furthermore, providing training to teams, providing necessary resources, and offering ongoing support will enhance the effectiveness of the process. Lastly, measuring the success of the Stage-Gate method through evaluating KPIs and ROI ensures the process aligns with organisational goals and drives desired project outcomes.

5.4. Limitations of the current study

The interaction between the researcher and participants was deemed to influence the data because they are employed by the same research centre where the study was conducted. This is because the participants may not be free to voice their honest opinions and as a result they will tell researcher what he wants to hear. Therefore, it was mandatory to appoint an independent research consultant to conduct interviews. Although, independent research consultant is a qualified researcher, she did not have in depth knowledge of Stage-Gate method and project management. This could have limited probing. The researcher organized a meeting with the independent researcher to explain Stage-Gate method and details of the research project. Furthermore, the researcher provided the independent researcher a proposal of this study, relavant articles and a background of the research centre. Power outages made scheduling very difficult because the meetings were held on the Zoom platform. For this reason, interviews were conducted at times where power is likely to be available and outside office hours. Therefore, some interviews were scheduled at unusual times which had impact on the participation. The small sample size limited the ability to generalize the findings to a wider population, hence a diverse sample was used to provide rich and relevant data.

5.5. Future research work

To date, academic research has adopted various business models to generate funding and to be sustainable. Therefore, it is not wise to keep the olden ways of running projects, where project timelines for instance do not matter. The mismanagement of R&D projects in academia is not the only issue and it is critical since commercialisation has become mandatory in boosting the economy and job creation. Therefore, future research should focus on the bottlenecks and management of university-industry partnerships. Furthermore, the adoption of an industrial R&D value chain in an academic environment should be explored. The impact of international collaboration should be looked into since it has challenges related to delays and intellectual property issues. Is South Africa doing enough in terms of R&D funding? Should the country rely heavily on international funding in exchange for its IP? Is the private and public sector doing enough to support academic R&D? Indeed, commercialisation in academic institutions should yield spin-off companies. Is the business model of the academic institution set up for industrial-scale demonstrations and manufacturing factories? These are some of the interesting topics and research questions to look into in the future.

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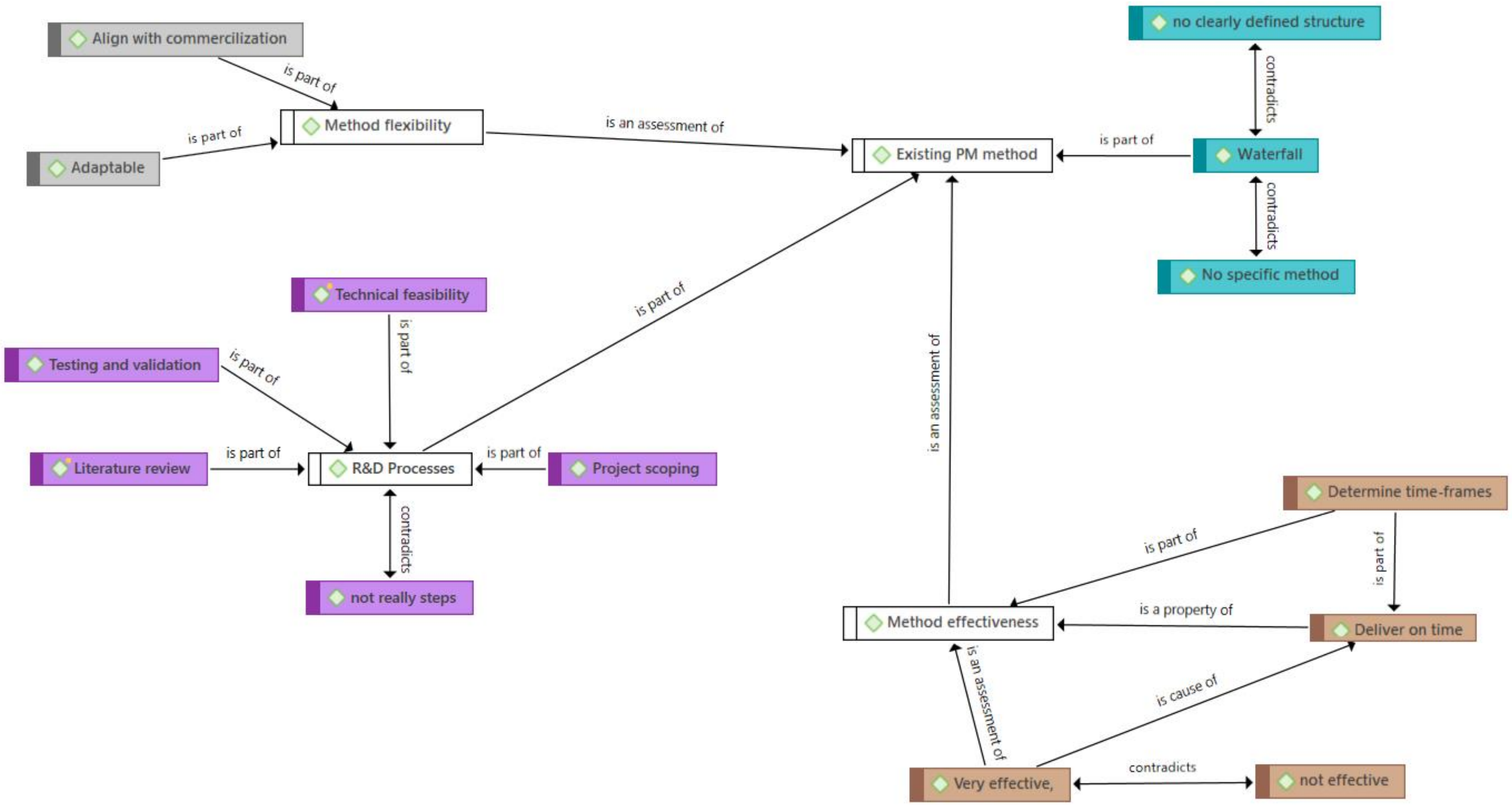
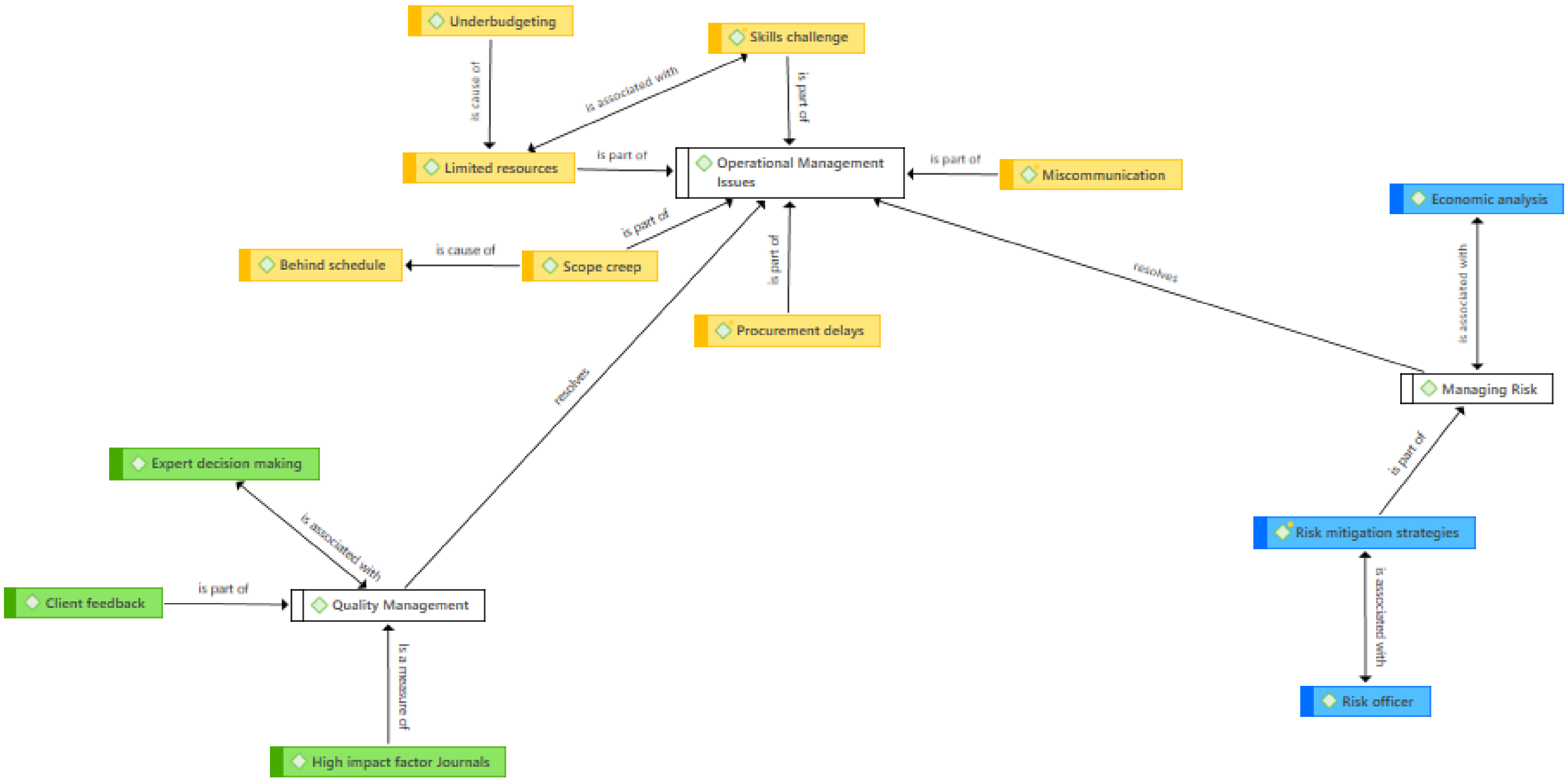
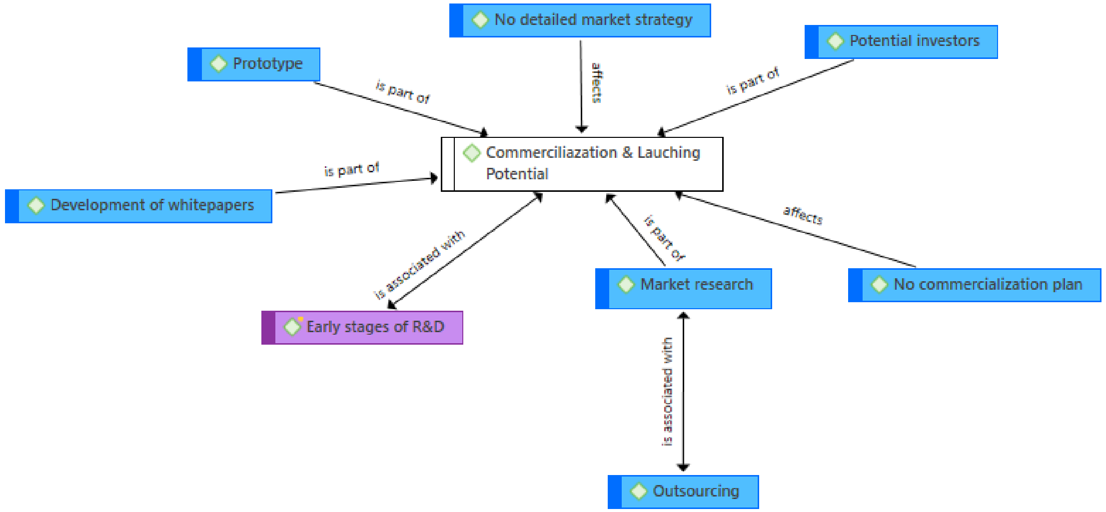
Appendix A1: Network diagram

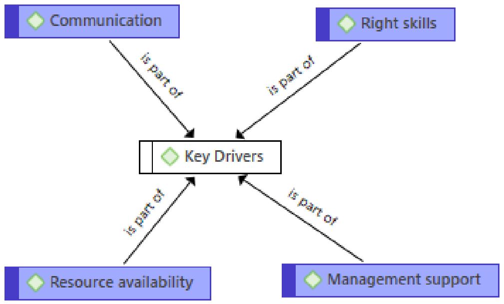


Appendix A2: Network diagram



Appendix A3: Network diagram





Appendix A4: Word cloud

Appendix B: Proof of language editing

To whom it may concern

Cecile van Zyl
Language editing and translation
Cell: 072 389 3450
Email: Cecile.vanZyl@nwu.ac.za

1 November 2023

Dear Mr / Ms

Re: Language editing of mini-dissertation (The application of a Stage-Gate method to manage projects at an academic research centre in South Africa)

I hereby declare that I language edited the above-mentioned mini-dissertation by PM Modisha (student number: 25816268).

Please feel free to contact me should you have any enquiries.

Kind regards

Cecile van Zyl

Language practitioner

BA (PU for CHE); BA honours (NWU); MA (NWU)
SATI number: 1002391

Appendix C: Measuring Instrument

Interview guide

Research title: Application of a Stage-Gate method to manage projects at an academic research centre in South Africa

Interview questions
Question 1. As you are involved in R&D activities within the centre, may you please describe the current project management method being used at the research and development centre? **Question 2**. In your opinion, does this method follow specific steps? Please elaborate and take me through the steps. **Question 3**. How does this method help to ensure that projects are completed on time and within the specified budget? **Question 4**. How effective do you think this approach might be in meeting the needs and expectations of all stakeholders, including funders?
Question 5. It is widely known that project management inevitably involves various challenges. May you walk us through some of the issues that have been encountered thus far? **Question 6.** How does the current project management method take into account factors such as risk management, resource allocation, and communication among team members and with external partners or clients?
Question 7. Given your background in R&D activities at your centre, can you elaborate on how Stage-Gate fit into current projects? **Question 8**. If Stage-Gate is introduced at your centre, in which way will this method improve the quality of outputs?
Question 9. In your opinion, what are the essential factors that would facilitate the effective adoption of the Stage-Gate method as a substitute management tool in your centre?
Question 10. Have you made any recent changes or improvements to the approach, and if so, what have been the outcomes? **Question 11**. How do you ensure that the approach is adaptable to different types of projects and able to meet evolving R&D needs?
Question 12. Is there a detailed plan such as market research for the product's development and launch? If so please describe how this plan is carried out.

Appendix D: Consent form

INFORMED CONSENT

Dear Participant

I am conducting research titled '**Application of a Stage-Gate method to manage projects at an Academic Research Centre in South Africa.** The aim of this study is to explore the implementation of the Stage-Gate method for managing research and development (R&D) projects at a research centre hosted by the North-West University, Potchefstroom Campus. Through online interviews, the selected participants will share their experiences regarding the R&D project phases from ideation to the launch phase. This will enable the researcher to customise and propose a specific Stage-Gate process tailored for the type of projects the research centre is currently undertaking.

The online interviews will be conducted with the employees who are involved in the core business of the research centre, i.e. engineers, scientists, artisans, and project managers. Please familiarise yourself with the attached consent document and provide a signature if you agree with the contents.

The interview will take approximately 30 to 40 minutes of your time.

The following is an outline of the steps that will be taken to store research data in a manner that safeguards it against unauthorised access, use, disclosure and loss.

- The access to research data (recordings, transcriptions, results and other relevant information) will be limited to the researchers involved in the work. This will be done by using passwords, access control lists, or other security measures to limit access to the data.
- Research data will be stored and regularly backed up on secure servers, hard drives and computers that are protected from unauthorised access by using passwords and safe storage.
- Secure methods such as encrypted email or secure file transfer protocols will be used to when communicating research data.
- After completion of the research and when research data is no longer needed, it will be disposed of securely, destroying physical paper records and securely erasing digital data.

I hereby confirm that

- I voluntarily *agree to participate* in this study.
- I understand that even if I agree to participate now, I c*an withdraw at any time or refuse to answer any question* without any consequences of any kind.
- I understand that I *can withdraw permission* to use data from my interview and/or written with an open-ended questionnaire in which case the material will be deleted.
- I have had *the purpose and nature of the study explained to me* and I have had the opportunity to ask questions about the study.
- I understand that the interviews will be recorded, and the time will not exceed 1 hour.
- I understand that participation involves being asked questions verbally and that *the data will be used as* part of the research work of the MBA programme.
- I understand that *I will not benefit directly* from participating in this research.
- I understand that all information I provide for this study will be *treated confidentially*.
- I understand that in any report on the results of this research *my identity will remain anonymous*.
- I understand that under freedom of information legalisation *I am entitled to access the information* I have provided at any time while it is in storage.
- I understand that I am *free to contact any of the people involved in* the research to seek further clarification and information.

Agree ☐ Disagree ☐ (Please tick)

Student Name: Phillimon Modisha Contact / cell.: 0722377846

Supervisor: Prof JN Lekunze Cell: 0837197640

Appendix E: Permission to conduct research

Private Bag X6001, Potchefstroom
South Africa 2520

Tel: +2718 299-1111/2222
Web: http://www.nwu.ac.za

Research Data Gatekeeper Committee

NWU RDGC PERMISSION GRANTED LETTER

Based on the documentation provided by the researcher specified below, on **07-November-2023** the North-West University (NWU) Research Data Gatekeeper Committee (NWU-RDGC) hereby **grants permission** for the specific project (as indicated below) to be conducted at the NWU:

Project title: Application of a stage-gate method to manage projects at an academic research centre in South Africa.

Project leader:Prof Phillimon Modisha

Researcher/Project Team:

Ethics reference no : NWU-0 0 61 2 - 2 3 - A 4

NWU RDGC reference no: NWU-GK-23-198

Approval date: 07-November-2023 **Expiry date**: 07-November- 2024

General Conditions of Approval:

- The NWU-RDGC will not take the responsibility to recruit research participants or to gather data on behalf of the researcher. This committee can therefore not guarantee the participation of our relevant stakeholders.
- Any changes to the research protocol within the permission period (for a maximum of 1 year) must be communicated to the NWU-RDGC. Failure to do so will lead to withdrawal of the permission.
- The NWU-RDGC should be provided with a report or document in which the results of said project are disseminated.
- Due to the COVID-19 pandemics the Committee would like to advice the researcher to practice the necessary caution and adhere to the National Covid-19 Guidelines when conducting research with participants.

Please note that under no circumstances will any personal information of possible research subjects be provided to the researcher by the NWU RDGC. The NWU complies with the Promotion of Access to Information Act 2 of 2000 (PAIA) as well as the Protection of Personal Information Act 4 of 2013 (POPI). For an application to access such information please contact Ms Annamarie De Kock (018 285 2771) for the relevant enquiry form or more information on how the NWU complies with PAIA and POPI.

The NWU RDGC would like to remain at your service as scientist and researcher and wishes you well with your project. Please do not hesitate to contact the NWU RDGC for any further enquiries or requests for assistance.

Prof Jeffrey Mphahlele

Chairperson NWU Research Data Gatekeeper Committee

Original details: (22351930) C:\Users\22351930\Desktop\test 2.docm
13 November 2018

Current details: (22351930) M:\DSS1\8533\Monitoring and Reporting Cluster\Ethics\Applications RDGC\Updated RDGC Permission Letter.docm
15 November 2018

File reference: 1.1.4.3

Appendix F: Ethical clearance

Private Bag X1290, Potchefstroom
South Africa 2520

Tel: 018 299-1111/2222
Fax: 018 299-4910
Web: http://www.nwu.ac.za

Senate Committee for Research Ethics
Tel: 018 299-484
Feziwe.Mseleni@nwu.ac.za

30 May 2023

ETHICS APPROVAL LETTER OF STUDY

Based on approval by the **Economic and Management Sciences Research Ethics Committee (EMS-REC)** on, 23/05/2023 the Economic and Management Sciences Research Ethics Committee hereby **approves** your study as indicated below. This implies that the North-West University Senate Committee for Research Ethics (NWU-REC) grants its permission that, provided the special conditions specified below are met and pending any other authorisation that may be necessary, the study may be initiated, using the ethics number below.

Study title: Application of a Stage-Gate method to manage projects at an Academic Research Centre in South Africa

Study Leader/Supervisor (Principal Investigator)/Researcher): Prof J Lekunze

Student: PM Modisha (25816268)

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Institution Study Number Year Status

Status: S = Submission; R = Re-Submission; P = Provisional Authorisation; A = Authorisation

Application Type:
Commencement date: 30/05/2023 **Risk:** **Minimal**
Expiry date: 30/05/2024

Approval of the study is initially provided for a year, after which continuation of the study is dependent on receipt and review of the annual (or as otherwise stipulated) monitoring report and the concomitant issuing of a letter of continuation.

Special in process conditions of the research for approval (if applicable):

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General conditions:

While this ethics approval is subject to all declarations, undertakings and agreements incorporated and signed in the application form, the following general terms and conditions will apply:

- *The study leader/supervisor (principle investigator)/researcher must report in the prescribed format to the EMS-REC:*
  - *annually (or as otherwise requested) on the monitoring of the study, whereby a letter of continuation will be provided, and upon completion of the study; and*
  - *without any delay in case of any adverse event or incident (or any matter that interrupts sound ethical principles) during the course of the study.*
- *The approval applies strictly to the proposal as stipulated in the application form. Should any amendments to the proposal be deemed necessary during the course of the study, the study leader/researcher must apply for approval of these amendments at the EMS-REC, prior to implementation. Should there be any deviations from the study proposal without the necessary approval of such amendments, the ethics approval is immediately and automatically forfeited.*

- *Annually a number of studies may be randomly selected for an external audit.*
- *The date of approval indicates the first date that the study may be started.*

  n the interest of ethical responsibility, the NWU-SCRE and EMS-REC reserves the right to:
  - *request access to any information or data at any time during the course or after completion of the study;*
  - *to ask further questions, seek additional information, require further modification or monitor the conduct of your research or the informed consent process;*
  - *withdraw or postpone approval if:*
    - *any unethical principles or practices of the study are revealed or suspected;*
    - *it becomes apparent that any relevant information was withheld from the EMS-REC or that information has been false or misrepresented;*
    - *submission of the annual (or otherwise stipulated) monitoring report, the required amendments, or reporting of adverse events or incidents was not done in a timely manner and accurately; and / or*
    - *new institutional rules, national legislation or international conventions deem it necessary.*

The EMS-REC would like to remain at your service as scientist and researcher, and wishes you well with your study. Please do not hesitate to contact the EMS-REC or the NWU-SCRE for any further enquiries or requests for assistance.

Yours sincerely,

Mark Rathbone

Digitally signed by Mark Rathbone
DN: cn=Mark Rathbone, o=North-West University, ou=Business management, email=mark.rathbone@nwu.ac.za, c=ZA
Date: 2023.05.30 10:35:59 +02'00'

Prof Mark Rathbone
Chairperson: NWU Economic and Management Sciences Research Ethics Committee